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BARGE TRAFFIC FORECAST AND CONSTRAINT ANALYSIS FOR GREAT II.(U)

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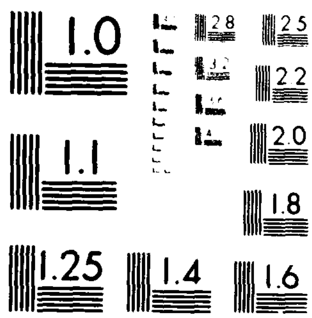

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CORPS OF ENGINEERS

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BARGE TRAFFIC FORECAST AND CONSTRAINT ANALYSIS FOR GREAT II.

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SUBMITTED BY

Kearney: Management Consultants

IN COOPERATION WITH

DATA RESOURCES, INC.

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ROCK ISLAND DISTRICT
CORPS OF ENGINEERS

FINAL REPORT

BARGE TRAFFIC FORECAST AND CONSTRAINT ANALYSIS FOR GREAT II

JANUARY 31, 1980

Submitted by
A. T. Kearney, Inc.
in cooperation with
Data Resources, Inc.

ROCK ISLAND DISTRICT
CORPS OF ENGINEERS

BARGE TRAFFIC FORECAST AND CONSTRAINT ANALYSIS FOR GREAT II

TABLE OF CONTENTS

TABLE OF CONTENTS (Cont'd.)

LIST OF TABLES

LIST OF TABLES (Cont'd.)

LIST OF FIGURES

LIST OF EXHIBITS

LIST OF EXHIBITS (Cont'd.)

I - INTRODUCTION

This study is divided into the following major chapter headings:

- Introduction.
- Barge Traffic Forecasts: 1979 to 2000.
- Constraint Analysis.
- Recommendations.

This chapter discusses the background, objectives, scope, and approach of the study. A more detailed statement of the approach taken in forecasting barge traffic and analyzing potential constraints is discussed in Sections II and III, respectively. Section IV summarizes study recommendations.

BACKGROUND

The Upper Mississippi River extends from Minneapolis and St. Paul to the mouth of the Ohio River and is a major avenue for commercial traffic. However, the Upper Mississippi has not always been a navigable river. Before any river development or improvements had taken place, the river was swift, shallow, and obstructed by rocks. In fact, in the early 1800s, the Upper Mississippi was not navigable to places like St. Paul during periods of low flow.

As outlined in River Transportation in Iowa, the technical capability of the Upper Mississippi River to support the present level of commercial traffic is attributable to a series of improvements and developments. In 1824, Congress authorized the Corps of Engineers to remove obstructions including snags, sandbars, and wrecks from the Mississippi. In the 1830s, passages through several rapids were made by dynamiting and excavating rock. Meandering sloughs and backwaters were closed off to confine flows to the main channel. In 1878, Congress authorized the first comprehensive project for improving the Upper Mississippi River by authorizing the Corps of Engineers to establish and maintain a depth of 4.5 feet between the Twin Cities and the mouth of the Missouri. Navigation was improved by this project as a result of the construction of short canals through several rapids. In 1907, Congress authorized a six-foot channel. Navigation was improved with the construction of hundreds of wingdams that forced the flow of the river into the main channel. (Wingdams extend into the river channel from the shoreline and are placed

at an angle to the river's flow.) In 1930, Congress authorized the construction of a nine-foot channel from the Twin Cities to the mouth of the Ohio River. This project was completed in 1940 and was by far the most ambitious of the river improvement projects. In addition to cutting rock, constructing wingdams, and dredging, the Corps of Engineers constructed a series of locks and dams to provide a series of lakes, referred to as pools, which provide the authorized depth for navigation during low flow. A total of 29 dams and locks were constructed. The Corps of Engineers was also authorized to maintain minimum river channel widths of 300 feet.

Since the completion of the nine-foot channel project, the Corps of Engineers has engaged in a variety of maintenance activities including dredging. The Mississippi River is a quick-shoaling river in continuous change despite the fact that the dams have been in place for 40 years. As a result of this continuous change, it has been necessary for the Corps to dredge at numerous locations to maintain an adequate depth and width for safe and efficient navigation. For example, the Rock Island District estimates that it typically must dredge at approximately 70 different locations over a period of 10 to 20 years. These sites represent less than one percent of the channel within the District.

During the early 1970s, the focus of public policy had shifted from development of the nation's resources to conservation. This shift in emphasis has affected the maintenance and development of the Upper Mississippi as well. In point of fact, the State of Wisconsin initiated a lawsuit against the St. Paul District of the Corps of Engineers. The suit was initiated by the Wisconsin Department of Natural Resources and charged that the St. Paul District was disposing of dredge materials in a way that might change the aquatic and plant life along the Wisconsin shoreline of the Mississippi. The Wisconsin Department of Natural Resources contended that the purpose of the suit was not to close the channel at points where dredging is required nor to stop all barge traffic.

In response to this lawsuit, the North Central Division Engineer of the Corps and the North Central Regional Director of the U.S. Fish and Wildlife Service established a partnership to try to work out a long-range management strategy for the development and maintenance of the Mississippi in an environmentally sound manner. These efforts have been combined into the Great River Environmental Action Team (GREAT). From 1974 to 1976, most of the GREAT activities focused on the Minnesota and Wisconsin portions of the Upper Mississippi River.

In 1976, Congress formally authorized the Corps of Engineers to investigate and develop, in cooperation with interested state and federal agencies, a river system management plan for the entire Upper Mississippi River. The authorizing legislation was under Section 117 of the Water Resources Development Act of 1976. To accomplish the objectives set by Congress, three study teams, GREAT I, II, and III, were established. The GREAT I study team is to develop recommendations for the portion of the river from the head of navigation in Minneapolis to Guttenburg, Iowa. The GREAT II study team is to develop recommendations for the portion of the river from Lock and Dam 10 at Guttenburg to Lock and Dam 22 at Saverton, Missouri. The GREAT III study team is to cover the river from Saverton to the mouth of the Ohio River.

Each GREAT study team is made up of a number of workgroups including commercial transportation, cultural resources, dredged material uses, dredging requirements, fish and wildlife management, water quality, recreation, sediment and erosion, side channel, flood plain management, material and equipment needs, public participation, and plan formulation.

The purpose of the Commercial Transportation Workgroup is to identify and document the needs of shippers and carriers who will use the Upper Mississippi River for commercial navigation in the future. The Commercial Transportation Workgroup includes representatives from the Coast Guard, Corps of Engineers, various state transportation agencies, barge and towing companies, and selected trade associations.

In support of the Commercial Transportation Workgroup, the Corps of Engineers contracted with A. T. Kearney, Inc. and Data Resources, Inc. (DRI). This report is an advisory report to the Commercial Transportation Workgroup of GREAT II. The findings, conclusions, and recommendations of this study are included as appropriate in this final report of the Commercial Transportation Workgroup, and subsequently in the GREAT II final report, and then in the Corps of Engineers' river management plan for Congress. The objectives, scope, and approach of this report are outlined in the following subsections.

OBJECTIVES

The primary objectives of this report to the Commercial Transportation Workgroup are threefold:

(1) To develop a forecast of the magnitude and nature of barge traffic in the GREAT II area,

(2) To forecast needs, such as barge fleeting, that will be necessary to support future barge traffic,

(3) To identify alternative means of meeting these needs.

Additional objectives of the report are to review the existing literature related to forecasts of barge traffic and needs in the GREAT II area and to summarize problems involved with the commercial development of the river.

SCOPE

The forecast period chosen for the analysis is 1979 to 2000. Many changes can occur over such a period of time. The current study cannot address all the issues that could possibly affect barge traffic in the future. As a result, Data Resources has focused its resources on examining potential effects of changing energy requirements by the Upper Mississippi River states. In particular, coal and petroleum products are forecast for a number of alternative scenarios. While other commodity groups certainly may experience shifts away from baseline conditions, only general discussions of these potential shifts were feasible.

Ideally, the study should have addressed any matter that acts to constrain the growth of barge traffic in the GREAT II area. Such constraints might have included:

1. Lock capacity.
2. Channel width and depth.
3. Navigational aids.
4. Horizontal and vertical clearance of bridges.
5. Legal constraints.
6. Terminals.
7. Barge fleeting areas.
8. Other uses of the river (e.g., recreation).
9. Availability of transportation equipment.
10. Winter navigation.
11. Environmental regulations.

From a practical point of view, limitations on resources available to the Commercial Transportation Workgroup made it necessary to focus on the more important constraint areas as determined by an analysis of both traffic projections and interviews with commercial users of the Upper Mississippi River. Every effort was made to focus on those constraints where an issue of public policy (as opposed to an issue that is addressed properly by shippers and carriers) was at stake.

APPROACH

The approach of the study involved the following major tasks:

- Literature review.
- Barge traffic forecasts: 1979 to 2000.
- Constraint identification and analysis.
- Costs of failing to address constraints.
- Recommendations for possible solutions.

Each of these major tasks is discussed below.

(a) Literature Review

A literature review was conducted to obtain any information that might be of use in forecasting barge traffic in the GREAT II area. Approximately 20 publications were reviewed. The techniques of forecasting marine traffic used by each author were discussed and compared to the method used by Data Resources for this study. The literature review is published under separate cover.

A separate literature review was undertaken to identify problems, needs, and opportunities associated with the commercial development of the river. Secondary sources were reviewed and a number of interested parties, such as chambers of commerce, planning commissions, state departments of transportation, selected shippers, and local officials were contacted. This literature review is also published under separate cover.

(b) Barge Traffic Forecasts to the Year 2000

The forecasting of barge traffic in the Rock Island District involved four phases. First, Upper Mississippi River barge traffic was forecast by commodity to the year 2000. Second, traffic terminating or originating within the Rock Island District to the year 2000 was allocated to district subareas using the 1977 waterborne commerce tape. This waterborne commerce tape contains information on the specific river segment from which a particular shipment originates and terminates. These specific areas are called port equivalent (PE) regions. Third, through traffic (i.e., traffic that passes through the Rock Island District) to the year 2000 by commodity was determined. Finally, the traffic was adjusted to reflect potential changes in river terminal locations in the future (such as new coal terminals in Iowa).

The first phase involved using 1965 to 1977 data on traffic originations and terminations on the entire Upper Mississippi River. For example, coal moves from both southern Illinois and Kentucky origins on the Ohio River to utilities on the Upper Mississippi. Coal also originates in Minneapolis (moving from Wyoming via Burlington Northern Railroad) and terminates at Upper Mississippi River utilities. Using forecasts of coal demand by utilities for West North Central region, information on rail competition as well as regional coal supply competition (e.g., western coal substitution for high-sulfur eastern coal), Data Resources, Inc. estimated total Upper Mississippi River demand for coal via barge through 2000.

The second phase concentrated on allocating waterborne commodity movements to subareas along the river. For example, a utility located in a certain port equivalent region would be examined for its growth relative to other utilities. Traffic growth was then allocated to individual regions based on both 1977 subregion shares by commodity and predicted share changes (such as a new power plant).

The third phase involved determining the share of commodity traffic forecasts that would be through (overhead) traffic. For example, some petroleum traffic originating in the Gulf terminates above the Rock Island District. Total overhead traffic plus originating and terminating traffic in the Rock Island District represents all traffic potentially moving through the Rock Island District.

The final phase integrated the Rock Island District forecasts

with other GREAT study forecasts. As an example, if GREAT I forecasts assume that new grain terminals will be constructed in the St. Paul District, this would imply higher through traffic in the future. Since the existing project does not encompass examination of all Upper Mississippi traffic shifts, we have had to rely on the other GREAT studies to provide such information as new utility plants and terminals located north of the Rock Island District.

(c) Constraint Identification and Analysis

Once the commodity forecasts had been made, A. T. Kearney began the process of identifying potential constraints that might reduce future traffic below forecasted levels. The constraints addressed in this study include:

1. Lock capacity.
2. Navigational constraints.
3. Legal constraints on commercial development.
4. Terminal capacity.
5. Fleeting space.
6. Winter navigation.
7. Conflicts with recreational use.

The approach involved in analyzing each of these potential constraint areas is outlined below.

1. Lock capacity. The analysis of lock capacity was made for each lock under alternative commodity scenarios for the years 1980, 1990, and 2000.

Several steps were involved in the lock analysis. First, the total tonnage passing each lock for each year was determined. This tonnage was categorized by type of commodity and direction of flow. Second, for each commodity movement, a specific type of barge lading, tow size, and tow configuration was specified. Third, shipper and carrier interviews were conducted to determine the factors influencing the availability of backhaul transportation. Fourth, the movement of loaded tows was adjusted for the movement of empties. Fifth, a specific type of lockage was specified for each tow. Sixth, the time required to lock each type of tow at each lock was estimated. Seventh,

the total time available for locking traffic was estimated for each season. In addition, hours of locking time lost due to turnbacks and stalls were estimated. Once this analysis had been completed, the locking requirements for projected 1980 traffic was compared with the actual locking performance for each lock in 1977.

2. Navigational constraints. Navigational constraints that presently restrict operations of carriers and shippers were identified by conducting field interviews with carriers and shippers. A. T. Kearney field interviews conducted for the National Waterways Study were also used in this analysis. The discussion of navigational constraints includes problems associated with inadequate channel width and depth; improperly placed or removed navigational aids; and bridges with inadequate vertical and horizontal clearance.

3. Legal constraints on commercial development. Problems associated with the commercial development of the river were identified by reviewing existing literature and conducting a limited number of field interviews.

4. Terminal capacity. The demand for additional terminal shipping or receiving capacity is a function of the increase in tonnage expected to be handled at ports throughout the Rock Island District. The projections provided by Data Resources supplied information on expected increases in originations and terminations for 24 commodity groupings. In view of budget limitations, it was determined that the demand for terminal capacity to handle increases in grain (corn, wheat, and soybeans) originations and coal terminations should be analyzed in some detail. Since grain and coal accounted for the largest increases in originations and terminations, respectively, it was felt to be appropriate to limit the analysis to these commodity groupings. The analysis was based on interviews with grain shippers and utility officials. Additional information was provided by interviews conducted by A. T. Kearney for the National Waterways Study and workpapers from prior A. T. Kearney studies for commercial clients.

5. Fleeting space. Fleeting areas are used for the temporary storage of loaded or empty barges. Typically, river terminals can handle only a few barges at a time. As a result, when a tow drops off 10 or 15 barges at a time for a particular terminal, the terminal operator will hire a fleeting operator to place one or two of these barges at his dock and store the remainder until needed. Inadequate fleeting space might restrict the growth of traffic in the Rock Island District and this potential constraint was also analyzed.

The analysis of fleeting space was conducted by interviewing all fleeting operators in the Rock Island District.

Factors that determine whether a particular stretch of the river is adequate for fleeting were identified. An inventory of fleeting capacity was then developed for each of 12 river segments in the Rock Island District. The estimated supply of fleeting space was then compared to the projected increase in terminations and originations for each of these 12 river segments. Areas where there might be a lack of adequate fleeting space in the future were identified.

6. Winter navigation. Freezing of the Upper Mississippi River during the winter months effectively brings barge transportation to a halt for much of the GREAT II area. The constraint caused by this freezing was not examined in detail because an economic analysis of year-round navigation on the Upper Mississippi has just been completed for the Rock Island District of the Corps. As a result, comments regarding this constraint are limited to that study.

7. Conflicts with recreational use. Potential conflicts with recreational users of the Upper Mississippi River were also analyzed. This analysis was based on interviews with carriers and a review of the existing literature on projected increases in recreational activity.

(d) Costs of Failing to Address Constraints

For some of the potential constraints identified above, A. T. Kearney attempted to estimate the possible costs associated with failing to provide acceptable solutions. These costs might include such things as higher transportation charges or increased risk of spills and consequent environmental damage.

(e) Recommendations for Possible Solutions

For each of the potential constraints, possible solutions were developed. Whenever possible, a range of solutions was discussed. For example, the possibility of increasing lock capacity in the short term by instituting alternative locking procedures and making modest physical changes to the locks was examined in some detail. Potential solutions were developed on the basis of A. T. Kearney analysis of traffic flow data and field interviews with commercial firms and government agencies.

II - BARGE TRAFFIC FORECASTS: 1979 to 2000

This section outlines the method of approach used by Data Resources to forecast commodity flows for the GREAT II area and presents the major findings from this analysis. The section is divided into the following major subsections:

- Background.
- General forecasting methodology.
- Agricultural traffic.
- Fertilizer traffic.
- Coal traffic.
- Petroleum traffic.
- Construction materials traffic.
- Other commodities traffic.
- Major findings.

The background subsection discusses the historical traffic data base used by Data Resources, while the subsection on general forecasting methodology provides an overview of the DRI models. The subsections on various commodity groupings discuss the commodity-specific forecasting approach and findings.

BACKGROUND

An examination of historical Rock Island District barge traffic, based on the Waterborne Commerce Statistics data published by the Corps of Engineers for 1969 to 1977, revealed that 25 commodity groups encompassed approximately 98% of total district traffic. Table II-1 contains these commodity groups. They form the basis for commodity forecasting of Rock Island District barge traffic. Due to variations in reporting procedures, the Waterborne Commodity Statistics data do not always agree with commodity data reported by individual Corps districts. Corps district reports are generally based on lockmaster information on commodities moving through locks, while the Waterborne Commerce Statistics data are reported directly to the Waterways Statistical Center in New Orleans by barge carriers. Data Resources has relied on the Waterborne Commodity Statistics data in its forecasting effort, primarily because of the greater commodity detail (the Corps district data report only four commodity groups: grain, coal, petroleum, and other).

Table II-1

Commodity Groups

General Commodity Group	Commodity Classification for Waterborne Commerce
Corn	0103
Wheat	0107
Soybeans	0111
Coal	1121
Sand, Gravel, and Crushed Rock	1442
Phosphate Rock	1471
Rock Salt	1491
Other Grain Mill Products	2049
Vegetable Oils	2091
Chemicals	2819
Nitrogenous Chemical Fertilizers	2871
Phosphatic Chemical Fertilizers	2873
Other Fertilizers	2879
Gasoline	2911
Jet Fuel	2912
Kerosene	2913
Distillate Fuel Oil	2914
Residual Fuel Oil	2915
Asphalt	2918
Lubricants	2916
Naphtha	2917
Crude Petroleum	1311
Cement	3241
Pig Iron, Coke, and Ingots	3300
Other Commodities	-

Source: Waterborne Commerce of the United States.

For each commodity group, waterborne traffic forecasts were developed for a number of traffic classes. Table II-2 on the following page contains a description of these classes. In addition, originations and terminations were reported by the 12 river segments (port equivalents) corresponding to the pools created by the Rock Island District Dams 11 through 22. Exhibits II-1 and II-2 contain a listing and map of the Upper Mississippi port equivalents.

The forecast period chosen for the analysis is 1979 to 2000. Many changes can occur over such a period of time. The current study and its limited resources cannot address all the issues that could possibly affect barge traffic in the future. DRI has focused its resources on examining potential effects of changing energy requirements by the Upper Mississippi River states.

Table II-2

Waterborne Traffic Definitions

Class	Definition
Total	All originating, terminating, within, or through traffic.
Within	Originates and terminates in a defined waterway segment.
Inbound	Originates outside and terminates in a segment.
Outbound	Originates inside and terminates outside a segment.
Upbound	Moving through, within, inbound, or outbound in an upstream direction.
Downbound	Moving through, within, inbound, or outbound in a downstream direction.
Port Equivalent (PE)(1)	For locked rivers, normally a dam and its pool.
	For unlocked rivers, a defined stretch of river.
	1975 - approximately 250 PEs were defined for inland waterways.

Note: (1) See listing and map of Rock Island port equivalents.

Source: Waterborne Commerce of the United States.

In particular, coal and petroleum products are forecast for a number of alternative scenarios. Other commodity groups certainly may experience shifts away from baseline conditions; however, only general discussions of these potential shifts were feasible, given existing time and budget constraints.

Exhibits II-3 and II-4 list the historical Rock Island District barge traffic by forecasted commodity groups and by concept. The forecasted commodities represent approximately 98% of total movements within the district. Certain commodity flows representing small or erratic shipments such as limestone, clay products, and textiles are not forecasted in this study. Since their inclusion would not affect the analysis substantially (their

forecasted values would have fallen within the standard errors of the existing forecasts), DRI decided to exclude these flows from the final analysis.

Historically, Rock Island District barge traffic has grown at an average annual rate from 1969 to 1977 of 4%. Increases in outbound and through traffic were responsible for total traffic growth, with agricultural shipments via water from Iowa the major commodity growth area. Overall, Rock Island District traffic is concentrated in three major areas: grains, petroleum products, and coal.

GENERAL FORECASTING METHODOLOGY

Data Resources, Inc. adopted the following general procedures in developing forecasts of Rock Island District barge traffic:

1. Develop a barge traffic forecasting model for the whole Upper Mississippi River in each major commodity class.

2. Use DRI industry models to forecast the major explanatory variables for the barge traffic models.

3. Develop a forecasting model for barge originating, terminating, and through traffic for the Rock Island District by commodity class.

4. Project baseline Rock Island District barge traffic, total and by concept, to the year 2000.

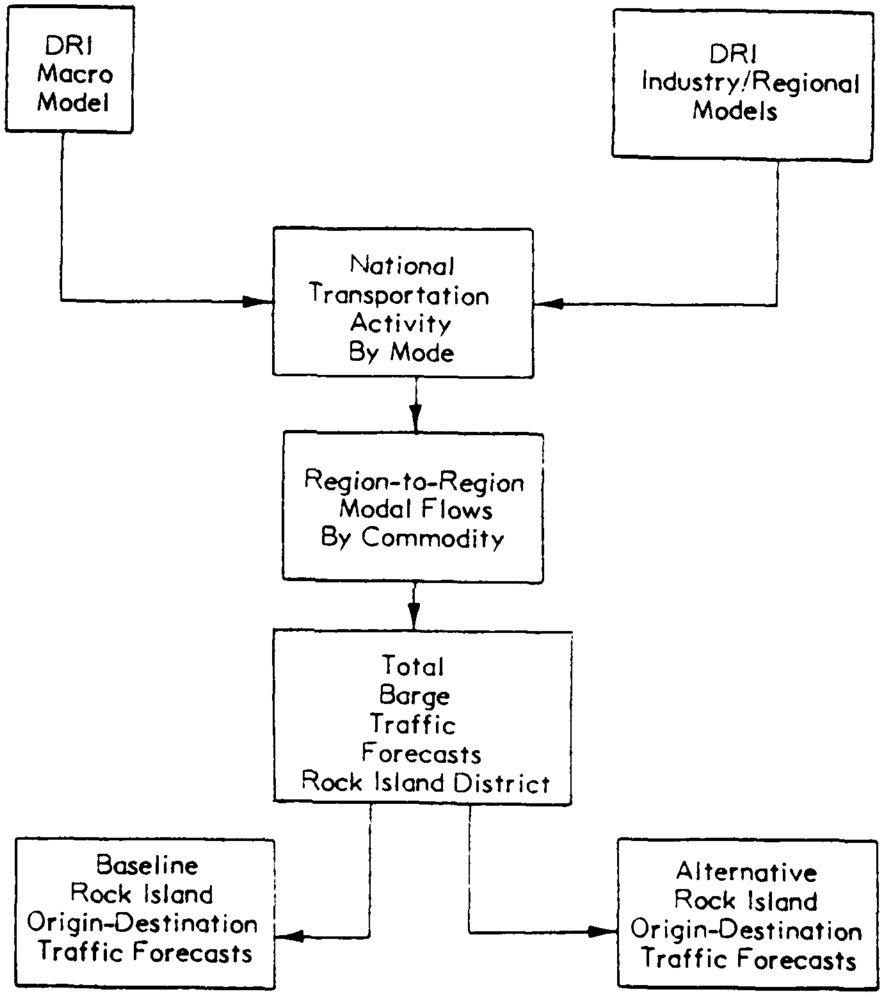
5. Allocate projected traffic flows to individual port equivalents on basis of historical shares and trends.

6. Perform alternative scenario analysis for commodity classes, such as coal and petroleum products.

Figure II-1 summarizes the DRI procedure for forecasting Rock Island District barge traffic. All DRI industry and transportation model forecasts are consistent with the Macro Model projections for the U.S. economy. For example, a macroeconomic simulation translates into industry production and shipment implications, which, in turn, have certain transportation requirements for raw materials and finished products.

Figure II-1

Rock Island District
Barge Traffic Forecasting Procedure - Model Flowchart



Source: DRI Transportation Service.

The national transportation demands by commodity further imply region-to-region traffic flows. Export corn moving via rail and barge from Illinois to the Gulf would be a typical movement. The Rock Island District waterborne corn flows for export represent a subset of the total grain export transportation demands.

Finally, terminal location within a district determines actual shipping or receiving points for regional transportation flows. Expansion plans for water-served ports or terminals determine changes in outbound or inbound flows, as do changes in regional economic activity.

The following subsections describe each part of the general forecasting procedure.

(a) Barge Traffic

In order to forecast total Upper Mississippi River or Rock Island District barge traffic, a forecasting model for each commodity group had to be developed. The following general forecasting equation was used:

$$V_{ij} = f(IA_i, T_i, R_i, P_{ij}, X_{ij})$$

where V_{ij} = Traffic volume by commodity i on mode j

IA_i = Industrial activity/sectoral demands for commodity i

T_i = U.S. foreign trade activity in commodity i (when relevant)

R_i = Regional activity measures for commodity i

P_{ij} = Modal competition factors (relative prices, etc.)

X_{ij} = Other factors (weather, strikes, etc.).

Historical (1964 to 1977) barge traffic data on commodity flows in and out of the Upper Mississippi River were obtained from the Corps of Engineers. Alternative modal price and traffic data were available from the DRI Transportation Service data banks. Regional activity measures and foreign trade data were developed in cooperation with the DRI industry services (Agriculture, Fertilizer, Coal, Petroleum, Chemicals, Forest Products, Steel, and others).

Using econometric estimation procedures, a forecasting equation was developed for Upper Mississippi River barge traffic for all 25 commodity groups listed in Table II-1. Although the equations included different explanatory variables, all equations related historical patterns of economic growth and, where likely, alternative mode competition to barge traffic over time. The

result is a methodology that estimated traffic through the year 2000 based on new forecasts of regional and other modal activity for a particular Rock Island District barge flow. In most cases, total Upper Mississippi River barge traffic was forecast based on both historical traffic shares between total Upper Mississippi River and Rock Island District traffic and projected share changes in the future.

(b) DRI Industry Model Forecasts

Once the forecasting models for Upper Mississippi River barge traffic were completed, projections of the explanatory variables (such as coal demands in the East North Central census region, exports of corn, gasoline demand in the Upper Mississippi River states, and new construction activity adjacent to the Rock Island District) had to be developed. In general, DRI chose explanatory variables that both replicate historical traffic variation and are forecasted by one of the DRI industry services. Table II-3 shows how the Rock Island barge traffic commodity groups were related to the DRI models used in forecasting explanatory variables.

Table II-3

DRI Industry Models and Barge Traffic Forecasts

DRI Model	Rock Island Barge Traffic Group
Agriculture	Grains, Grain Mill Products, Agricultural and Food Products
Fertilizer	Phosphate Rock, Fertilizer Materials, etc.
Coal	Bituminous Coal
Energy	Petroleum Products
Chemical	Basic Chemicals, etc.
Macro/Regional	Construction Aggregates (sand, gravel, cement)
Steel	Steel Products and Raw Materials
Transportation	Salt, Other Modes Traffic (pipeline, rail)

Source: DRI Transportation Service.

DRI used the latest U.S. Macro Model long-term (to year 2003) solution as the basic U.S. economy simulation. The corresponding long-term simulation for each industry model provides

the forecasts of explanatory variables for the commodity-specific Upper Mississippi barge traffic models. The assumptions surround-each industry model forecast and the implications for transportation are discussed in detail under each major commodity heading.

(c) Rock Island District Barge Traffic Model

The preceding paragraphs discuss the process for projecting total Upper Mississippi River traffic by commodity. Forecasts that identified within district, inbound, outbound, and through traffic for the Rock Island District were also developed. In addition, specific origins and destinations by commodity within the Rock Island District had to be identified.

Using the 1969 to 1977 Waterborne Commodity Statistics for port equivalent origins and destinations within the Rock Island District, historical trends in intradistrict and through traffic shares were used to project forecasted shares. Three procedures were used. For traffic shares that have changed consistently over time, the level and rate of movement in the share was preserved in the future. For constant or near constant traffic shares, the 1977 level was used. Finally, if recent changes in shares occurred, then an average of the most recent changes was used.

Thus, historical traffic shares by concept (within, inbound, outbound, through) and by port equivalents within the Rock Island District were translated into equations that converted total Upper Mississippi barge traffic forecasts by commodity into estimated district activity.

(d) Rock Island Traffic Forecasts

Using the Rock Island District barge traffic model district origin and destination forecasting model, and the DRI industry model forecasts, projections of barge traffic to the year 2000 were developed for the baseline scenario. A number of alternative scenarios are evaluated for the major Rock Island barge commodity classes: coal, petroleum, and grains. Emphasis in the alternative forecasts is on regional industry shifts or changes in competitive modes. These forecasts and alternative scenarios are discussed in detail below. Exhibit II-5 presents Rock Island District traffic forecasts by concept and commodity for the baseline scenario.

AGRICULTURAL TRAFFIC

Agricultural traffic includes grains (corn, wheat, and soybeans) as well as grain products. Grains and grain products will be discussed separately.

(a) Grains

Background material, forecasting approach, and forecasts are discussed below:

1. Background. The inland waterway role in the grain distribution system is overwhelmingly to carry grain to points of export. In 1977, 98% of Mississippi River corn and soybean barge traffic was destined for points at Baton Rouge or below. For wheat, the Gulf share was only 85%, with much of the remainder going to domestic mills on the Tennessee River, a stable, saturated market. The major river shipping areas differ for each grain. Corn, for example, is originated predominantly by terminals located on the Illinois and Upper Mississippi rivers with a growing market share coming from the Lower Ohio River. While these same rivers play a key role in soybean shipments, the Lower Mississippi River, the Mid Mississippi River (between the mouth of the Illinois River and Cairo), and the Gulf area account for a large, growing market share for this product. The Upper Mississippi River generates almost half of all Mississippi River system wheat traffic (more in a strong export year), with most of the remainder coming from the Lower Mississippi, Illinois, and Missouri rivers.

The Rock Island grain traffic includes through and outbound traffic. Outbound traffic is dominated by corn and soybeans. These shipments come to the river by rail and truck from many origins located typically west of the river. In order for grain companies to originate corn for shipment to the Gulf by barge, they must pay a higher price to local elevators and farmers than the price that processors, feedlots, or rail shippers are willing to pay. Grain companies can pay these higher prices often due to the relatively low cost of shipping by barge. Shipment of corn to distant domestic markets from the traditional originating area of the river is not common. As the cost of shipping to river terminals increases, alternative shipment channels become more attractive; the higher rail or truck gathering costs to river terminals more than offset barge linehaul rate advantages. Far enough west of the river, direct rail export via Pacific Coast ports becomes advantageous. Shipments of soybeans by barge face a similar competitive environment, except processors (crushers) are a more significant market, while direct feeding is not important. Through traffic in the

Rock Island District consists of a significant volume of wheat, in addition to corn and soybeans. While corn traffic from shipping points in Minnesota faces the same competitive factors as the outbound traffic described above, it also competes with direct export shipments from grain terminals located at Duluth and Superior.

Because of these traffic patterns, the Upper Mississippi River, including the Rock Island District, is sensitive to the mix and level of grain exports. A strong export market for wheat and, to a lesser extent, corn encourages movement out of this area. All other things equal, shorter hauls and better equipment utilization are possible for soybean traffic originating in other growing areas.

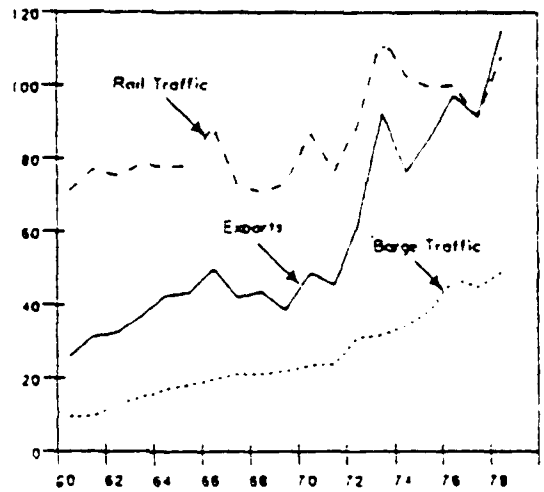
The nature of modal competition for grain is complex. The complexity is enhanced by the fact that railroad rates for a particular shipment are fixed at any point in time, while barge spot rates fluctuate, reflecting changes in product demand and equipment supply. During the course of a year, the barge rate to New Orleans may fluctuate by a factor of three or four.

The nature of competition between rail and barge reflects the relative pricing flexibility of the two modes. While a large portion of the barge fleet is not for hire or under long-term contract, a significant portion of the fleet is available to handle spot traffic. Spot rates fluctuate dramatically. When the export market is soft, spot barge rates fall until all barges are occupied. When demand rises, rates on the spot market increase to a point where excess demand is reduced. Market tightness in railcars, on the other hand, is reflected in car shortages or surpluses; rates are fixed at any point in time.

Because of this pricing environment, rail traffic exhibits more variability as grain exports fluctuate than do barge loadings, which have tended to increase continuously with the trend in exports over the last two decades (see Figure II-2). In years of tremendous export growth, railroad grain traffic normally increases significantly, while barge loading shows more restrained growth. Then, as the covered barge fleet gradually increases with additional barge construction, barge traffic continues to grow even in those years when a grain export boom has been followed by a bust. Thus, following a strong export year, barge traffic tends to remain firm or grow while rail traffic typically fails to hold its peak market share.

Figure II-2

Total Exports, Rail Shipments, and
Barge Shipments of Corn, Wheat, and Soybeans
(Millions of Tons)



Source: DRI Transportation Service.

2. Approach. The forecasting approach for Rock Island District barge traffic is a three-step process. First, the export market for corn, wheat, and soybeans is projected by the Data Resources, Inc. Agriculture Service. Within the DRI Agriculture Model, future U.S. production, acreage, exports, and domestic disappearance (among other measures) for each major grain and oilseed are determined by expected world production and demand in conjunction with behavioral relationships representing U.S. consumption and production activity. All key interactions in production and use are internal to the forecast process.

Second, the barge share of the export market is projected based on the adjustment of barge fleet size to increasing export demand. Historically, this share has tended to adjust toward a 50% share of the export market. In the long run, the barge share will rise if barge costs (plus access charges) increase more slowly than rail rates.

The DRI Transportation Service barge and rail cost models were used to identify the expected future course of relative modal costs. The rail cost model, which takes as inputs the projected inflation for approximately 20 key railroad cost components (including fuel, labor, and materials), indicated that railroad operating costs will increase at an average annual rate of 9.0% over the study forecast horizon. Translation of this

cost growth to a rate measure requires the analyst to make assumptions about railroad pricing policy during the final two decades of the century. Over the last 12 years, railroad freight rates as measured by general freight rate increases have averaged only 80% of operating cost increases. During the period 1960 to 1967, the industry asked for negligible rate increases in spite of steadily rising costs. If the unit train coal rate escalation clauses currently being written by western railroads are any guide, we may expect the railroads to seek future rate increases between 80% to 100% of operating cost increases or between 7.2% and 9% per year. Rate increases coupled with expected increases in private fleet costs imply an average annual inflation in rail grain shipping costs of between 7.5% and 8.5%.

The DRI barge cost model estimates changes in the annual costs (including equipment ownership) of any specified fleet of barges and towboats based on projected inflation of key purchased inputs to waterway operations including fuel, labor, equipment, crew subsistence, etc. The average annual increase in fleet ownership and operating costs from 1979 to 2003 was estimated to be between 7.7% and 8.1%, right in the middle of the range of expected rail increases.

The projections in this study reflect this relative consistency in the relationship of rail rates and barge costs over the forecast horizon. Several factors could affect this assumption. For example, congestion on the inland waterway system (either in the Rock Island District or below) could increase barge operating costs for this area. The purpose of this study is to identify such constraints with the Rock Island District. Congestion at facilities below the district are outside the scope of the GREAT II study.

Similarly, imposition of a higher waterway user fee than the fee that has thus far been legislated could lead to significant diversion of grain from the river system. For example, a two-year-old Department of Transportation study of waterway user charges suggests that the establishment of fuel taxes to recover 100% of government operations and maintenance costs on the inland waterway system (a significantly higher portion than in the current legislation) could divert up to 10% or 20% of river grain traffic, particularly for the long-haul shipping areas such as Minneapolis-St. Paul.

Many industry analysts feel that the railroad industry response to a permanent increase in barge costs would be to raise rates by a comparable amount. This would reflect a profit-oriented rather than a traffic-oriented strategy. Such a profit strategy is encouraged by the major capital requirements faced by the rail industry as the nation enters an era of greater coal dependence.

The third and final step in the Rock Island District grain forecast is the allocation of barge grain traffic to Upper Mississippi River and Rock Island District origins. Several attempts to relate the market share of that area with grain production in adjacent states failed due to lack of significant correlation. An examination of annual Upper Mississippi market shares of total barge traffic for each grain indicated significant fluctuations but no clear trends. The possibility of a market share loss to origins on the Ohio and Lower Mississippi rivers was explored and then rejected when preliminary data for 1978 to 1979 did not support such a suggestion. A fixed market share for the Rock Island District was assumed in each instance.

3. Forecasts. U.S. grain exports grew at an average annual rate of 9% to 12% during the 1960s and 1970s depending on the particular interval chosen, reflecting a 13% to 17% annual growth in corn and a 9% to 11% annual increase for wheat and soybeans. During that same period, barge grain traffic grew at similar rates. Data Resources sees continued growth in grain exports over the next two decades, but at slower rates of increase. The 3% to 4% annual growth rate currently anticipated for export grain is only a third of the growth rate for the last 10 to 15 years, yet it will still represent more than a doubling of the all-time record export performance of 1978 by the year 2000. As in the past, the growth in grain exports to the end of the century is expected to be led by corn.

Given the slowing growth of grain exports, the growth of grain shipments by barge will also moderate over the forecast horizon. Total grain shipments by barge are expected to grow at a 3.4% annual rate from 1978 to 2001, led by corn exports which grow at 4% per year, wheat at 3.4%, soybeans at a lower 2.6%. Rock Island District grain traffic is expected to grow slightly faster than total inland waterway grain traffic because of its relatively heavy mix of corn and wheat. In 2001, corn will continue to be the dominant commodity in the Rock Island District, accounting for 16.7 million tons. Wheat and soybean tonnages will be 4.3 and 3.8 million tons respectively. At 24.8 million tons, total barge grain traffic will roughly double over the 22-year forecast. The previous doubling from 6 to 12 million tons required only 9 years from 1969 to 1978.

(b) Grain Mill Products

1. Background. As in the case of grains, shipments of grain mill products (CCWC Code 2049) by barge are heavily oriented toward the export market, with over 90% of shipments destined for export at Lower Mississippi River and Gulf ports. This product group, which consists primarily of soybean meal and lesser quantities of other dry milling products, has been one of

the fastest growing commodities over the past decade, increasing 300% between 1969 and 1977 (15.6% average annual growth), in spite of an actual decline in 1977. This remarkable growth has occurred in a period during which exports have grown only 5.7% per year. The reconcilation of these apparently conflicting trends is the fact that the share of exports moving by barge through Lower Mississippi River and Gulf ports has risen dramatically over the period, while Atlantic and Gulf Coast exports have declined absolutely as well as relatively.

Rock Island District barge soybean meal traffic increased an astounding 1,200% over the 1969 to 1977 time frame, an average annual growth rate of 42.8%. The high rate of increase is due in large part to the small base year tonnage. The Upper Mississippi River barge share of total exports rose from 1.7% in 1969 to almost 14% in 1977.

2. Forecasts. DRI expects exports of grain mill products to grow over the next two decades at a rate slightly below historical levels, namely 4.5% per year for the period 1977 to 2001. Barge traffic will also continue to grow, but only marginally faster than exports, if only because the current market share of 75% to 80% will be hard to increase. The Upper Mississippi River and the Rock Island District will continue to obtain a larger market share of total barge grain mill traffic, but at a lesser rate than the last 10 years. Over the 1978 to 2001 time frame, DRI expects total Rock Island District grain mill product traffic to grow at just over 6% per year, increasing its export market share of the river segment from 14% to 25%.

FERTILIZER TRAFFIC

Fertilizer traffic in the Rock Island District consists primarily of nitrogen and phosphate fertilizers. This subsection contains discussions of background material, forecasting approach, and traffic forecasts.

(a) Background

Barge chemicals traffic in the Rock Island District consists almost entirely of the movement of fertilizers into the Upper Mississippi basin.

Fertilizer materials travel long distances from the origin of raw materials to the final consuming area. The great majority of phosphates are mined in Florida, while New Mexico and Saskatchewan are responsible for most potash production. Nitrogenous fertilizers typically originate in Louisiana or the Southwest, but the geographic distinction is not nearly as pronounced

as it is in the case of phosphates and potash. The Midwest (defined as Illinois, Iowa, Missouri, Indiana, Minnesota, Ohio, Michigan, and Wisconsin) consume one-third of the fertilizer products. These origin/destination patterns result in commodity flows that move by cheap bulk transportation. Rail, water, and pipeline handle practically all of the long-distance movements of fertilizer.

Forecasting barge activity in fertilizers is difficult. First, the traffic includes three major nutrients (phosphatic chemical fertilizers, nitrogenous chemical fertilizers, and potassic chemical fertilizers), two miscellaneous mixtures (fertilizers and fertilizer materials, n.e.c.), and two major raw material categories (phosphate rock and basic chemicals, n.e.c.). Second, one of the commodity codes (basic chemicals, n.e.c.) includes anhydrous ammonia in addition to a large variety of other chemicals unrelated to fertilizer production. A flow-by-flow, facility-by-facility analysis was required to establish that, for the Rock Island District, this commodity is nearly all ammonia. However, there is some controversy over whether all ammonia or just the ammonia destined for further processing is so categorized, with ammonia destined for direct application being coded as nitrogenous chemical fertilizers. Third, each of the fertilizer commodity groups in turn includes a number of different forms of product, each with its own nutrient concentration and shipping characteristics.

The forecast is made even more complex by the fact that shipments may occur at varying points in the production process, as transportation and raw material costs change. Thus, nitrogen may enter the Rock Island District in a number of forms and on several alternative modes. First, natural gas may be piped into the region for the purpose of being processed into ammonia in the vicinity of consuming sites. Second, ammonia may be produced or imported at the Gulf and shipped north by barge, pipeline, or rail. Third, the further processing to other nitrogenous forms (urea, ammonium nitrate, and nitrogen solutions) may occur at the Gulf with rail or barge shipment north under a different commodity designation - "nitrogenous chemical fertilizers" as opposed to "basic chemicals". Finally, the nitrogen materials might be combined with phosphatic material from Florida at the Gulf and shipped by rail or barge as monammonium or diammonium phosphate yet another commodity classification. All four of these production and distribution strategies exist side-by-side in the Upper Mississippi River basin, with one riverfront operation receiving pipeline ammonia at the front door and barge ammonia at the back door.

(b) Approach

The forecasting approach for fertilizer chemicals involved a three-step process. First, the DRI Agriculture Service Model was used to estimate national and regional grain production and acreage for each major grain. These forecasts were generated in the same model solution as the grain and grain mill product export projections, guaranteeing internal consistency between the results. The DRI Fertilizer Model, which is a submodel of the Agriculture Model, also provided consistent growth rates for nutrient application.

Second, econometric models of acreage by crop were developed for Iowa, Minnesota, and Wisconsin. Illinois and Missouri, which also border the Rock Island District, were excluded because the larger share of their nutrient arrives via other river segments or other modes. The acreage for each crop was then converted into regional requirements for each nutrient based on historical usage in the region and the growth rates in usage (amount per acre and extent of application) projected by the DRI Fertilizer Model.

Third, growth rates in nutrient requirements were applied to base year traffic levels to determine future levels of barge traffic. The implicit assumption here is that nutrient will enter the system in the future in roughly the same mix and manner as in the base year (1977). Barge fertilizer flows into the Rock Island District have fluctuated significantly in the past decade both in level and mix, making clear distinction of trends in particular subgroups difficult. There is some possibility, for example, that nitrogen transportation in the form of urea has been increasing relative to ammonia movement. Although urea is less concentrated that ammonia, implying greater shipment weight per ton of nutrient, the barge equipment required is considerably less expensive. Whether this apparent trend will continue depends on a number of factors including preferred form of application (direct application ammonia must obviously be shipped as ammonia) and source of the nutrient (industry source indicates that distribution economics encourages barge shipment when the material arrives by ship at Baton Rouge). Because both the solution to this complex production and distribution problem would constitute a large study in itself and alternative futures for industry direction entail many countervailing impacts, the conservative approach of fixing base year distribution patterns was adopted. It should be noted that when the simplification leads to commodity misclassification, as opposed to modal misallocation, the impact on system requirements and results is minimal.

(c) Forecasts

Fertilizer nutrient demand in the Upper Mississippi River basin is projected to grow at an annual average of 2.3% for nitrogen, 2.5% for phosphorous, and 2.0% for potassium. Because it was assumed that the basic logistics pattern would remain constant, upbound barge traffic in the nitrogenous commodities (basic chemicals, n.e.c.; and nitrogenous chemical fertilizer) is projected to grow also at that rate, increasing by a factor of 72% between 1977 and 2001. Total ammonia traffic is expected to increase somewhat less rapidly, because a portion of the total ammonia traffic in the Rock Island District involves localized shipments.

Phosphatic chemical fertilizers and phosphate rock shipments into the district are expected to increase 78% over the forecast period. The modest differential in growth between the two nutrients reflects the fact that different amounts of each are used for each crop type. For example, soybeans are a nitrogen-fixing crop and require very little application of that nutrient.

Fertilizers and fertilizer materials, n.e.c. are projected tc increase at a weighted average growth rate of phosphorous and nitrogen demand, because that commodity group is comprised of the ammonium phosphate compounds, which satisfy requirements for both nutrients. Because the barge potassium movements in the district are both small and oriented to nutrient demand outside the Rock Island District, the basic forecasting methodology was not applied to these shipments. Instead, these shipments have been included in the "all other commodities" group.

COAL TRAFFIC

This discussion of coal traffic includes a presentation of several alternative scenarios for Rock Island coal traffic growth. This section is divided into the following subsections:

- Background.
- Approach.
- Long-term coal outlook.
- Forecasts.

(a) Background

The Rock Island District is both a major consumer of coal and

an important link in the coal distribution system for Upper Mississippi utilities. Exhibit II-6 summarizes the annual waterborne coal traffic flows for the district from 1969 to 1977. During that time, inbound traffic has grown from 30% to 39% of total district traffic, with through traffic accounting for the remaining 61%. A recent phenomenon has been the growth of downbound/inbound traffic into the district, reflecting the increasing use of western coal by utilities in the upper portion of the district.

The long-term trend has been towards declining levels of through coal traffic as the Upper Mississippi River utilities around Minneapolis have switched to western coal. The major Upper Mississippi utilities with waterborne coal delivery are listed in Exhibit II-7. These plants use coal either traversing or terminating in the Rock Island District at the present time. The utility plants located north of the Rock Island District account for the majority of the western coal usage on the river. Formerly, eastern coal from Illinois and Kentucky was shipped by barge to these plants. Recent air quality regulations have resulted in the increased use of western coal to avoid expensive scrubbing costs associated with the continued use of high-sulfur eastern coal in the region. The receipt of western coal at these northern plants has directly substituted for through traffic of eastern coal via the Rock Island District. As can be seen by Exhibit II-7, 42% of the total coal use by water-served Upper Mississippi River utilities was from western sources in 1977; this is a six percentage point increase over 1976. The trend towards western coal use is likely to continue and accelerate in the Upper Mississippi River utilities as stricter clean air regulations are enforced in the period through 1983.

As can be seen by Exhibit II-7, the plants located within the district mainly rely on eastern coal, with some western coal use by utilities in the upper end of the district. The basic distribution pattern for these utilities is as follows:

1. All eastern coal is delivered by barge from Illinois, Kentucky, and other origins with little or no rail competition.

2. Western coal is brought to the Mississippi River near Minneapolis and transferred to barge for final delivery.

3. At present, no western coal moves off the Upper Mississippi River to other utilities. Western coal destined for plants located on or near the Illinois or Ohio rivers is trans-loaded at terminals in East St. Louis, Illinois; Havana, Illinois; or Demopolis, Illinois. Since most of the Upper Mississippi River plants formerly received eastern coal via water, the western coal

must be put on the river for final delivery, even though the waterborne movement may be only 25 miles in some cases.

Exhibit II-8 shows the results of a Federal Energy Regulatory Commission survey of Upper Mississippi River utilities in 1978 as to their new plant sitings, fuel type, and proposed mode of transportation. Only the expansion of the Interstate Power's Lansing plant is likely to add new coal traffic (above present growth rates) to the Rock Island District, since most expansion is occurring above or below Rock Island District boundaries. Further, many of the newer plants are to be served directly by rail, eliminating the need for the short-haul barge movements. Finally, western coal is the most likely fuel for most of the new Upper Mississippi utilities, implying that barge will only play a short-haul role in much of the new coal traffic.

(b) Approach

DRI's coal demand projections are based on a detailed examination of many macroeconomic factors which, through simulating the DRI Model of the U.S. Economy, lead to projections of industrial production indices, employment levels, vehicle sales, housing starts, various price indices, and other relevant factors. These macroeconomic variables are fed into the DRI energy consumption model and the fuel demands for each of five energy-consuming sectors are forecast.

For major energy consuming sectors (electric utilities, industrial steam, coking, household, commercial, and synthetic fuel), the trade-off between coal and other fuels is examined. This analysis is based on both policy and regulatory issues as well as the price and availability of various energy sources in each of 13 energy-consuming regions of the U.S.

Prior to forecasting Upper Mississippi River and Rock Island District barge coal traffic, an extensive analysis of the end-markets and potential supply sources had to be undertaken. Since utilities attempt to minimize their delivered cost per million BTU for fuel, a number of switches among supply regions may occur over the life of an electrical generating facility. The key to forecasting coal demand by a utility and, thus, modal traffic patterns is understanding how delivered coal prices from alternative supply sources to a region are likely to change in the future.

The first phase of the analysis involved using the DRI Coal Model to determine from which regions water-served utilities

located on the Upper Mississippi River will receive their coal in the future. Estimating total Upper Mississippi River waterborne coal traffic required analysis of both end-market demands as well as modal competition. Exhibit II-9 depicts the final forecasting equation used in determining Upper Mississippi River barge coal traffic. Coal demand in the West North Central and East North Central census regions and a factor explaining changing market share of waterborne versus rail traffic were the principal explanatory variables.

The forecasts of end-market demand for coal were provided by the DRI Coal Service, based on the latest CONTROL forecasts of May, 1979. Market shares by mode were assumed to remain constant through the forecast period for most scenarios, although they were altered for a special scenario, called MKTSHR. The MKTSHR scenario will be discussed under the subsection Forecasts.

Next, a model of Rock Island District coal traffic was developed. Total Rock Island coal flows by barge were assumed to be a variable share of total Upper Mississippi coal barge traffic in the forecast period. The variability was based on whether increasing western coal use at Upper Mississippi River utilities would reduce upbound eastern coal movements passing through the Rock Island District.

Based on 1977 traffic data, Rock Island District coal traffic was then divided into major traffic classes: internal, inbound/upbound, inbound/downbound, outbound/upbound, outbound/downbound, through/downbound, and through/upbound. In addition, the Rock Island coal traffic moving by barge was allocated to destination port equivalents using 1977 PE shares of terminating Rock Island coal flows.

Finally, alternative forecasts were examined in order to give a range of results to the decisionmakers.

(c) Long-Term Coal Outlook

For total U.S. coal consumption, a strong market is expected to evolve in the last two decades of this century. A number of factors will contribute to the growth in coal demand, including increases in electricity consumption during the next decade of 4.5% per year, the expected rapid rise in oil and natural gas prices, and government regulations designed to increase coal utilization. Exhibit II-10 indicates that coal consumption is expected to grow at an annual rate of 5.1% between 1980 and 1990

and at an annual rate of 3.7% between 1990 and 2003. Coal's share of total U.S. energy consumption is expected to increase steadily from 18.3% in 1978 to 19.0% in 1980, 24.5% in 1990 and 30% in the year 2000.

Electric utilities will contribute the major increase in new coal demands. As can be seen by Exhibit II-10, total utility coal use is forecast to increase from 535 million tons in 1980 to 696 million tons in 1985 (a 5.4% annual rate of increase) and to 902 million tons by the end of 1990 (a 5.3% annual growth rate). This growth is expected to take place in spite of many uncertainties surrounding coal use by utilities.

Table II-4 details the outlook in total coal demand for the two census regions served by the Upper Mississippi River, the East North Central (ENC) and West North Central (WNC). In the short term through 1985, coal use in the WNC region is expected to grow at rates above the national average. Growth rates of coal use in the ENC region will fall slightly below the national average. These findings are primarily due to the coming on-stream of a number of new coal-fired utilities in these regions. In the long term (1985 to 2000), the growth rate for coal use in these regions will likely be below the national average growth. Coal-fired utility plants are already a substantial share of electricity generating capacity in these regions, implying that further substitution of coal for other fuels will occur at a slower rate than for other regions. Nuclear power also plays a significant role in electricity generation in these regions.

Table II-4

Projected Coal Demand for Upper Mississippi River Regions(1)

Demand Region	Million Standard Tons						Percent Change(2)				
	1977	1980	1985	1990	1995	2000	1977-1980	1980-1985	1985-1990	1990-1995	1995-2000
ENC(3)	234.1	248.0	293.9	360.9	421.5	474.3	1.9%	3.5%	4.2%	3.2%	2.4%
WNC(4)	58.8	71.5	99.5	135.0	161.1	186.9	6.7	6.8	6.3	3.6	3.0
U.S. Total	710.0	776.0	973.0	1,229.0	1,531.0	1,798.0	3.0	4.6	4.8	4.5	3.3

Note: (1) One standard ton equals 22.0 million BTU. Regional demand for domestically produced bituminous coal is computed as the sum of electric utility, industrial (both steam and metallurgical), residential, commercial, exports, and synthetic fuel plants demand for coal.
(2) Percent change is the compound annual rate of change.
(3) The East North Central region includes Ohio, Wisconsin, Illinois, Indiana, and Michigan.
(4) The West North Central region includes Kansas, Nebraska, North Dakota, South Dakota, Minnesota, Iowa, and Missouri.

Source: DRI Transportation Service.

Significant shifts in regional coal production are expected to occur in the next quarter century. North Appalachia is expected to maintain a fairly moderate growth rate of about 3% annually between 1978 and 1995, at which time its production will peak at 260 million tons. A similar phenomenon is expected to occur in Southern Appalachia, where production of coal is forecast to peak by 1990 and decline thereafter. The outlook for midwestern coal is bright, given the depletion of low-sulfur reserves in South Appalachia and the growth in coal demand in the South Atlantic region. However, the midwestern coal will tend to move South rather than supplant western coal use by Upper Mississippi River utilities. Western coal is forecast to be the fastest growing region for production in the country in the next 25 years.

(d) Forecasts

This subsection discusses a number of scenarios evaluated for Rock Island District coal traffic through the year 2000. These scenarios include the baseline, eastern coal growth, increased barge market share, new coal terminal, and increased western coal use:

1. Baseline forecast. Rock Island District coal traffic is projected to grow at an average annual rate of 4.6% between 1978 and 2003, increasing from 4.721 million tons to over 10 million tons during the forecast period. The major factors behind the projected coal traffic growth are:

(a) Continued growth in utility demands for coal; and

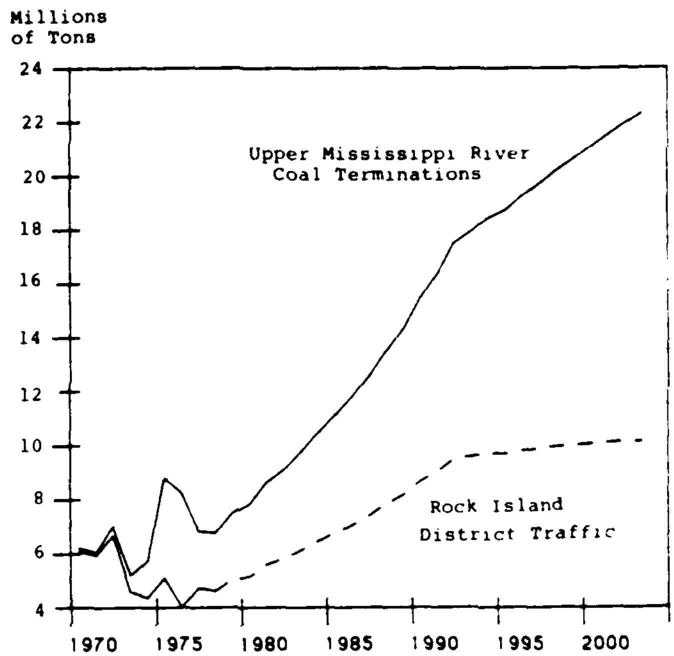
(b) Revised environmental regulations that may slightly increase barge-originated, midwestern coal use by utilities located on the Upper Mississippi River.

Coal traffic is expected to grow in the district at an annual rate of 3% through 1980, 6.8% from 1980 to 1990, and 2% from 1990 to 2003. The high growth rate from 1980 to 1990 reflects the coming on-line of a number of new coal-fired facilities in the region served by the Upper Mississippi River.

Figure II-3 summarizes the relationship between total waterborne coal traffic on the Upper Mississippi and Rock Island District coal traffic. The principal difference between total and Rock Island traffic represents shipments of western coal that originate and terminate north of the Rock Island District.

<u>Figure II-3</u>

Projected Upper Mississippi River Coal Terminations
and Rock Island District Coal Traffic



Source: DRI Transportation Service.

Table II-5 on the following page presents the results of alternative scenario analyses for Rock Island District coal traffic. Each of the other scenarios will be discussed below.

2. <u>Eastern coal growth forecast</u>. The first alternative scenario for Rock Island coal traffic assumes that eastern coal use by Upper Mississippi, water-served utilities increases by one-half of one percent per year through the year 2003. This scenario would result in a reversal of a long-term declining trend in eastern coal consumption at Upper Mississippi River utilities. The scenario assumes that the revised National Source Performance Standards (NSPS) will favor using some eastern coal in the region. Existing boiler configurations and potentially cheaper costs of transportation via barge are factors that could contribute to the decision.

Under the eastern coal growth forecast, total Rock Island District traffic is expected to increase by 5.7% annually through 1980, 11.2% per year from 1980 to 1990, and a 4.4% annual rate for the 1990 to 2003 period.

Table II-5

Rock Island District Barge Traffic Forecasts for Coal
(Millions of Tons)

Scenario	1977	1980	1985	1990	1995	2003	Annual Percent Change
CONTROL(1)	4.721	5.158	6.756	8.672	9.686	10.143	4.6%
EAST(2)	4.721	5.531	8.131	11.700	14.633	18.326	12.0
MKTSHR(3)	4.721	5.882	8.093	9.905	10.823	11.142	5.0
TERMINAL(4)	4.721	5.158	7.256	9.422	10.685	11.142	5.0
WEST(5)	4.721	5.158	6.756	8.672	9.686	10.143	4.6

Notes: (1) CONTROL is the baseline forecast and assumes that western coal use will increase at a compound rate of 1.5% per year to year 2003, substituting for Illinois coal.

(2) EAST assumes that eastern coal use will increase by one-half of one percent per year to year 2003.

(3) MKTSHR assumes that barge transportation will increase its market share of Upper Mississippi coal traffic.

(4) TERMINAL assumes that a new coal terminal will be built above the Rock Island District with one million tons throughput by year 2003.

(5) WEST assumes that western coal use will increase by 2.0% per year in the Rock Island District.

Source: DRI Transportation Service.

3. Increased barge market share scenario. A related scenario assumes that waterborne coal traffic will gain some additional modal share from rail as the result of adding new boiler capacity at water-served utilities rather than at inland plants. DRI altered the models to allow an additional one million tons to be moved to such plants by the year 2003. Under this alternative, coal traffic via barge in the Rock Island District is assumed to grow at 8.2% per year from 1977 to 1980, at 6.8% per year from 1980 to 1990, and at 1.4% per year from 1990 to 2003.

4. New coal terminal scenario. This alternative forecast assumes that a new rail-to-river coal terminal will be built in the Rock Island District. The principal movements are assumed to be downbound shipments to terminations other than on the Upper Mississippi River. The terminal is assumed to become

active in 1983, with initial throughput of 500,000 tons per year until 1985, rising to 750,000 tons per year until 1993, and one million tons per year by 2003.

Under the new coal terminal scenario, traffic via the Rock Island District is the same as the baseline forecast until 1983. For the 1980 to 1990 decade, barge coal traffic grows by 8.3% per year on average and by 1.4% per year from 1990 to 2003.

5. Increased western coal use scenario. The final alternative forecast analyzed for coal traffic in the Rock Island District assumed that western coal use would increase by 1.5% per year (in line with historical trends) for the forecast period, resulting in an increase in inbound/downbound traffic and a decrease in inbound/upbound movements (coal from Illinois). DRI did not alter total coal use in the district; only the direction of the traffic flows was altered.

As compared to the baseline forecast, inbound/upbound traffic is 12.5% lower in 2003 while inbound/downbound traffic has increased by an equal amount.

PETROLEUM TRAFFIC

This commodity group includes a variety of petroleum products, such as gasoline, jet fuel, and kerosene, distillate fuel oil, residual fuel oil, and asphalt. The forecasts for each of the petroleum products will be discussed under separate headings. A subsection describing the general forecasting procedure used for all petroleum product barge projections will precede the individual commodity discussions. The concluding subsection will discuss alternative scenarios of petroleum product traffic.

(a) Approach

The following general forecasting procedure was used for all the petroleum product barge projections:

1. Examine trends in end-market demands by petroleum product for Upper Mississippi River states - Minnesota, Wisconsin, Iowa, Illinois, Missouri. (The regional energy forecasts on which the barge traffic projections are based are presented in Exhibit II-11).

2. Relate these end-market demands to Upper Mississippi barge traffic, including consideration of pipeline competition in the lighter distillate oils.

3. Determine Rock Island District barge traffic as a

share of Upper Mississippi River shipments, including any potential future shifts.

4. Check forecast reliability via other techniques, including industry surveys.

5. Finalize forecast by correcting for structural shifts in historical relationships (e.g., modal competition, energy conservation).

An econometric forecasting equation was used to predict total Upper Mississippi River (St. Louis to Minneapolis) barge traffic. Rock Island District petroleum traffic by product was then determined as a share of total Upper Mississippi traffic forecasts. The simulation model then divided the traffic into Rock Island District flows as well as port equivalent terminations within the district. (For lubricants and naphtha, no within-district breakdown was provided since all traffic in these commodities was through traffic in the historical period and no terminations within the district are expected in the forecast period.)

For all petroleum products, 1977 within-district PE termination shares were used to forecast these destinations in the future. Since major terminals typically serve as the end-point to petroleum moves, it was assumed that any increase in products shipped would be handled by expansion of these locations rather than construction of new petroleum terminals at other locations in the district. When significant trends in PE shares occurred in the historical period, these trends were included in the forecasts.

(b) Waterborne Gasoline Traffic

Over the last decade, barge traffic moving to or through the Rock Island District has provided 3% to 5% of total gasoline consumption in Minnesota, Wisconsin, Iowa, Illinois, and Missouri. Due to pipeline competition, the barge share of gasoline shipments has fallen slightly, although waterborne traffic tends to serve areas without direct pipeline operations. Most gasoline moving into the Upper Mississippi River area by barge moves first by pipeline to St. Louis (or is refined in St. Louis) and then by barge. According to 1977 Waterborne Commerce Statistics, less than 12% of gasoline terminations on the Upper Mississippi originate from terminals located on the Lower Mississippi or the Gulf.

Exhibit II-12 presents the final forecasting equation used for Upper Mississippi barge traffic terminations. The primary explanatory variables were:

1. Upper Mississippi River gasoline demand by state.

2. Pipeline competition.

3. A variable to account for the 1973 to 1974 energy shortage and bad weather problems on the river.

DRI Energy Model forecasts of future gasoline consumption in the Upper Mississippi River states and DRI Transportation Service forecasts of the Gulf to Midwest pipeline flows of gasoline are used to project the traffic.

While gasoline consumption in the five-state area is forecast to grow only 7% over the 25-year period (due to more efficient automobiles and conservation), barge traffic is expected to increase by 40%, or about 1.5% per year. The major reason for growth in barge traffic is that barges, with their low ratio of energy use per ton-mile, can more efficiently deliver bulk gasoline to river points than can the less fuel-efficient tanker trucks. Table II-6 shows the projected barge traffic for the various petroleum products. Figure II-4 illustrates the change in barge shipments of gasoline over the study period.

Table II-6

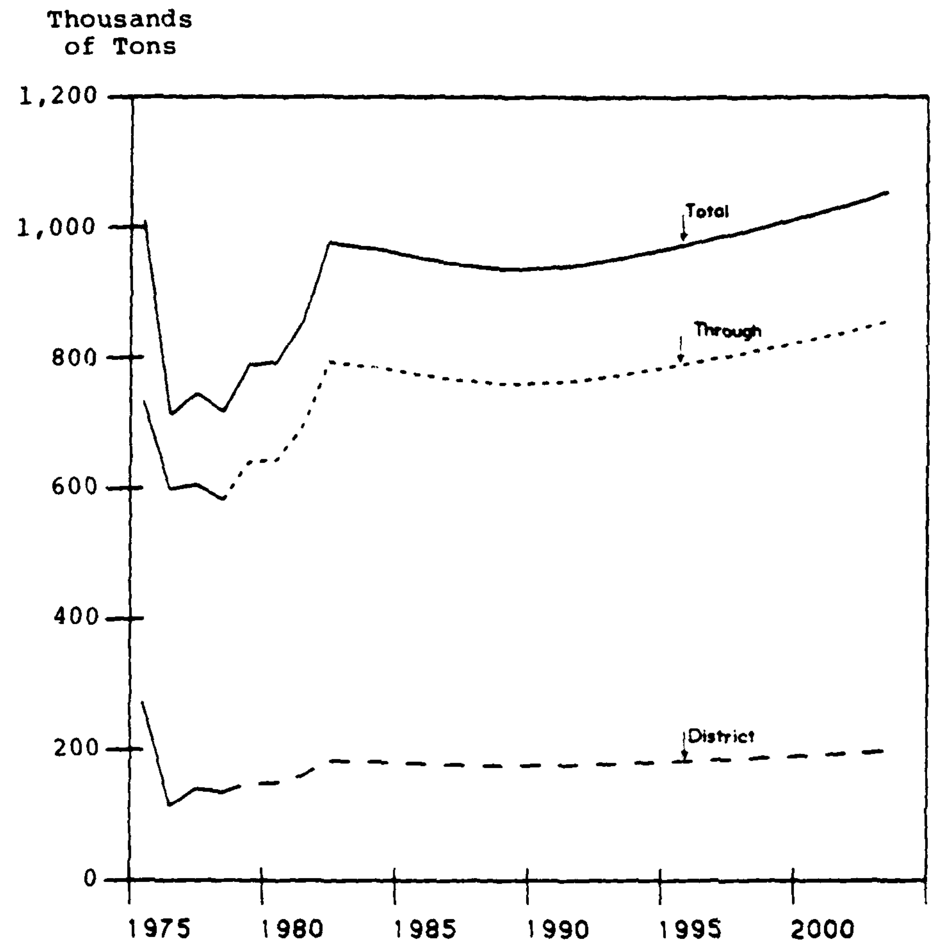
Projections of Rock Island District
Barge Traffic for Petroleum Products
(000s Tons)

Commodity (CCS Code)	1977	1980	1985	1990	1995	2000
Gasoline (2911)	745	792	956	937	970	1,081
Jet Fuel (2912) and Kerosene (2913)	96	121	136	148	155	161
Distillate Oil (2914)	497	571	937	1,147	1,221	1,282
Residual Oil (2915)	189	163	181	187	157	145
Asphalt (2918)	316	343	394	452	519	596
Lubricants (2916)	53	56	63	70	79	90
Naphtha (2917)	22	24	28	33	40	50
Total, All Products Forecast	1,900	2,070	2,695	2,974	3,141	3,342
Annual Rate of Change, Percent	-	3.0%	6.0%	2.1%	1.1%	1.3%

Source: DRI Transportation Service.

Figure II-4

Rock Island District
Barge Traffic - Gasoline



Source: DRI Transportation Service.

(c) Waterborne
Jet Fuel and
Kerosene Traffic

Barge has delivered a declining share of total jet fuel and kerosene demand to the Upper Mississippi River states over the last few years. During the last five years, the waterborne share has varied between 1% and 3% of total jet fuel consumption. As in the case of gasoline traffic, a major factor has been pipeline competition, especially to Minneapolis.

The distribution process for jet fuel is almost identical to gasoline. Kerosene and jet fuel are barged or piped to St. Louis and then transshipped to Upper Mississippi River destinations. Kerosene traffic has been a very small flow, averaging only 10,000 to 20,000 tons over the last five years. DRI does not expect much change in kerosene traffic through 2000. The DRI barge traffic forecast includes a fixed level of 15,000 tons of kerosene traffic (all through traffic). A formal econometric model for forecasting kerosene traffic was not developed.

The final forecasting equation for Upper Mississippi jet fuel traffic is presented in Exhibit II-13. The independent variables are:

1. Upper Mississippi states' demand for jet fuel.

2. Pipeline movements of jet fuel from the Gulf to the Midwest.

These variables are not good estimators of barge traffic, but they worked better than all other factors tried. Given that barge traffic is about 1% of total jet fuel demand, it is understandable that the equation is not that sensitive to normal demand measures.

Jet fuel consumption is forecast by the DRI Energy Service to grow by 58% over the 25-year period, or an average of 2% per year. Total barge traffic in jet fuel and kerosene is expected to increase about 50%, relative to 1976 to 1977 average traffic levels (see Table II-6). Given that the barge market share is so small, these forecasts are subject to relatively higher errors of estimate than other petroleum products.

(d) Distillate Fuel Oil Traffic

Distillate fuel oil provides fuel both for home heating, industrial uses, on-highway uses, and diesel off-highway uses. Much of the distillate movement to the Upper Mississippi River states is destined for use in farming operations. During the past decade, waterborne distillate fuel traffic has accounted for between 3% and 6% of total demand for distillate in Minnesota, Wisconsin, Illinois, Iowa, and Missouri. These states have historically accounted for about 12% of total distillate fuel use in the United States. Most of the waterborne distillate fuel that terminates in Upper Mississippi River states originates on the Mississippi River near St. Louis.

Major changes in distillate fuel use by end-market are expected in the Upper Mississippi River states by the year 2003. As shown in Exhibit II-11, fuel oil use at utilities is expected to be completely phased out over the next quarter century. In addition, the percentage of homes heated with distillate oil is expected to decline about 2% to around 13% of total housing units. New homes will tend to be heated with electricity and some existing homes using oil will convert to electricity. The major growth sectors are expected to be transportation and farming. As dieselization of both on-highway and off-highway vehicles increases rapidly in the next 25 years, the demand for gasoline will tend to level off and the consumption of diesel fuel will grow rapidly. Since farming activity is expected to grow in response to new export markets for U.S. grains, Upper Mississippi River states are likely to increase their consumption of diesel in proportion to the increased farm lands under cultivation.

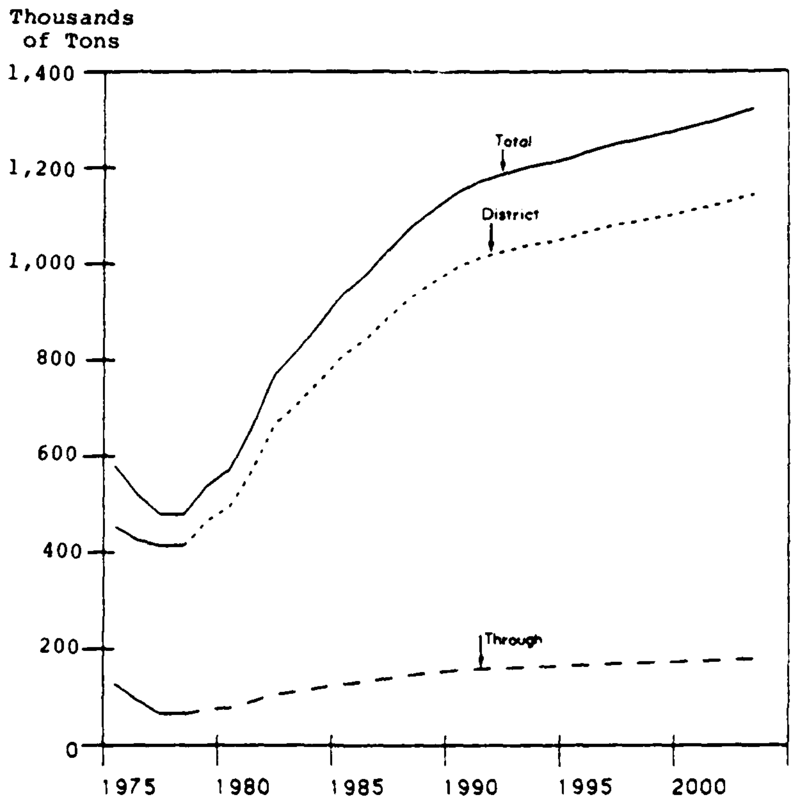
Exhibit II-14 depicts the forecasting equation used to predict Upper Mississippi River distillate fuel oil traffic. As in the previous equations, both Upper Mississippi River demands for distillate fuel oil and pipeline competition are the major explanatory variables. Since pipeline movements substitute for barge movements to many parts of the Upper Mississippi River states, the pipeline variable indicates that some traffic that could move via barge goes by pipeline. The primary reason is cost; pipeline transportation of light distillate oils is about one-third as expensive as barge movements. However, barge serves many areas not reached by pipeline and has a stable market for the future, provided additional pipeline capacity is not constructed to serve river locations.

Distillate fuel oil consumption is forecast to increase from 153 million barrels in 1977 to 278 million barrels in 2003, for an annual rate of increase of about 3.3%. The forecast growth rate for total barge traffic is approximately 6% per year (see Table II-6). Since most Gulf to Midwest pipelines do not serve river areas of the Upper Mississippi states, DRI expects barge to pick up an increasing share of total distillate fuel movements to these states. The barge market share is expected to rise to 8% of total Upper Mississippi River states distillate consumption by the year 2003. The major risk to the forecast is that increased pipeline capacity will be added to serve this region, resulting in substantially lower barge traffic. This possibility is explored in the concluding subsection on alternative scenarios.

Figure II-5 presents a comparison of the total Rock Island waterborne distillate fuel oil traffic and selected concept movements. The DRI baseline forecast indicates that most of the traffic growth will occur within the district rather than as through traffic.

Figure II-5

Rock Island District Barge Traffic - Distillate Fuel Oil



Source: DRI Transportation Service.

(e) Residual Fuel
Oil Traffic

Residual fuel oil is primarily used as a boiler fuel for industrial power plants or electric utilities. Most residual oils are highly viscous and cannot be piped over long distances. Generally, residual oils must be heated prior to transfer into storage tanks, transportation equipment, or boilers. Barge transportation moves a large share of total inland U.S. residual fuel traffic due to the specialized transportation requirements of the fuel. Barges equipped with heating units move residual oils to final upriver destinations from Gulf Coast refineries. The only competition to barge is rail; however, waterborne movement is much cheaper for most operations. Rail is generally used to transport residual fuel oil to inland, non-water served locations. The barge market share of total Upper Mississippi River states

residual fuel use has been highly variable in the past decade, ranging from less than 1% to well over 10%. Such fluctuations make the barge residual traffic particularly difficult to model. Barge movements of residual fuel oil to Upper Mississippi destinations have also been highly variable in recent years, ranging from 9,704 tons in 1970 to 188,471 tons in 1977.

These wide fluctuations in residual fuel oil traffic made it necessary to adopt a modified forecasting equation. Exhibit II-15 presents the revised estimation procedure used for waterborne residual oil traffic. It was necessary to include a market share variable in the residual fuel equation, allowing the analyst to specify the barge share of total Upper Mississippi River states residual oil use. The residual fuel demand variable was also included in the equation. For the baseline forecast, DRI assumed that barge would have a historical average share of 5.5% of Upper Mississippi River states residual fuel oil use. Total demand for residual oils is expected to fall about 1% per year. Barge traffic is expected to decline at the same rate (see Table II-6). Most traffic (75%) is through traffic and is expected to remain that way until 2003. The major risk in the forecast is the possibility of a complete cessation of residual fuel use by Upper Mississippi River utilities by the year 2003. This potential major traffic shift is examined in the concluding subsection.

(f) Asphalt Traffic

Asphalt is used for roadbuilding and construction. Asphalt traffic into and through the Rock Island District has grown steadily in the past decade, increasing from 174,000 tons in 1969 to almost 316,000 tons in 1977. Given the high viscosity of the product, asphalt tends to move via water or rail to final destination. Most waterborne asphalt traffic traversing the Rock Island District originates from refineries near St. Louis or on the Ohio River.

DRI has no direct measures of regional asphalt supply or demand and does not forecast regional demands for asphalt in the Energy Service. DRI does forecast the national demand for asphalt based on total vehicle miles traveled and construction activity. Since the Upper Mississippi River states were found to follow U.S. trends in the growth of both construction activity and vehicle miles traveled, DRI used this national forecast of demand for asphalt to estimate regional demand. It was assumed that no shift in barge modal share would occur in the forecast period. This assumption is reasonable, because waterborne movements account for a large percent of all asphalt flows into the region.

Rock Island District barge traffic in asphalt is forecast to grow at an annual rate of 4.2% over the next 25 years (see Table II-6). The primary rationale behind the strong growth in asphalt demand is the need to substantially rehabilitate the interstate highway system as well as primary and secondary roads. Maintenance is expected to be above normal in the last quarter of the century due to the heavy use the system has received in its first 20 years of operation.

(g) Other Petroleum Products

Barge traffic in petroleum products other than those examined in previous subsections is almost exclusively through traffic for the Rock Island District. Crude petroleum, lubricants, and naphtha all move to destinations north of the Rock Island District. In 1977, this traffic accounted for about 25% of total Rock Island District petroleum products movements by barge. This other petroleum traffic consists mostly (90%) of crude oil flows. Crude oil does move by pipeline, but this particular crude oil flow moves to a refinery that is not served by a pipeline. Naphtha and lubricants normally move by barge or rail.

As in the case of asphalt, DRI does not forecast any regional series relating to consumption of crude oil, naphtha, or lubricants. In order to forecast this barge traffic, national demand forecasts for the primary end-market factors were used. For crude oil, domestic crude production was used. For lubricants, the total demand for lubricants in the U.S. was used. Finally, the U.S. demand for naphtha was employed to forecast Rock Island traffic in naphtha.

Crude oil traffic is expected to grow slowly, perhaps one-half of one percent per year through the year 2000. The primary reason for the slow growth is that no new refineries using barge crude oil are expected to be built above the Rock Island District in the forecast period. Normally, these refineries are served by pipeline, given that the Upper Mississippi River is closed for three to five months per year due to ice conditions. Lubricants waterborne traffic is assumed to grow at an annual rate of just over 3.0% through the year 2003. Naphtha traffic is expected to increase by about 6.0% per year (see Table II-6). Other petroleum products, n.e.c. accounted for about two barge loads of traffic via the Rock Island District in 1977 and was not forecast.

(h) Total Petroleum Traffic

Total Rock Island District petroleum products traffic is expected to increase about 4% per year between 1977 and 1990 and about 1.3% per year from 1990 to 2003 (see Table II-6). The slowing of the growth rate in petroleum products is directly related to the substitution of other energy sources for the increasingly more expensive petroleum.

(i) Alternative Scenarios

This subsection examines only a few of the more likely alternative scenarios that would result in different flows than the baseline forecast. Perhaps the forecast subject to the greatest amount of forecasting error is distillate fuel oil. Increased pipeline competition could reduce the waterborne share to current levels. This would mean that approximately 850,000 to 900,000 tons would move by barge, a level of traffic 33% lower than the baseline forecast. DRI considers this possibility to be high, given the ease with which pipeline capacity can be expanded relative to other modes.

Residual fuel oil movements in the Rock Island District could decline to very small levels by the year 2003 if Upper Mississippi River utilities and industry convert to alternative fuels. Although DRI forecasts fairly flat traffic in residual oils through the next 25 years, the traffic may actually disappear.

Asphalt traffic could level off or grow at a much slower rate if highway rehabilitation programs are cut back due to problems in the highway trust fund. At present, sufficient funding for road repairs in the mid-1980s from the trust fund is questionable.

Crude oil movements are unlikely to increase and could easily fall to low levels if pipelines were able to meet the refinery needs currently moving via water in the forecast period. DRI rates such an event as a likely possibility in the mid-1980s.

Finally, the impact of waterway user charges (even at 100% recovery of the costs of operations, maintenance, and rehabilitation) are not expected to threaten petroleum traffic on the Upper Mississippi River any more severely than pipeline competition. User charges could hasten the decline of residual fuel use in Upper Mississippi River boilers and make new pipeline capacity additions for lighter distillates economically feasible at an earlier date.

CONSTRUCTION MATERIALS TRAFFIC

Data Resources examined two major types of construction materials traffic within the Rock Island District:

1. Sand, gravel, and crushed rock.

2. Cement.

Due to the changing nature of both industries, significantly different forecasts resulted.

(a) Sand, Gravel, and Crushed Rock

In general, due to the highly competitive nature of the sand and gravel industry (sand and gravel are abundant in most areas) and the low value of the material ($1.50 to $2.50 per ton depending on the quality and the region of the country), sand and gravel distribution occurs in very localized markets, such as the Quad Cities area (Davenport, Bettendorf, Moline, and Rock Island) of the Rock Island District. Traffic generated by sand and gravel movements consists almost entirely of short-haul shipments in which barge and rail transport play a minor role relative to trucking.

The vast majority of water shipments of sand and gravel in the Rock Island District originate at dredging facilities on private property adjacent to the river. Private firms use the river for the transport of dredged material from locations not directly on the river to sites ranging around 20 to 30 miles from the dredging area. Barges are either filled with dewatered sand moving on a conveyor system or filled directly and moved onto the waterway. Private barge activity of this nature used to annually account for 800,000 tons of sand and gravel (in the early 1970s), but, lately due to competition from landside quarries and environmental restrictions, the traffic has fallen to 300,000 tons.

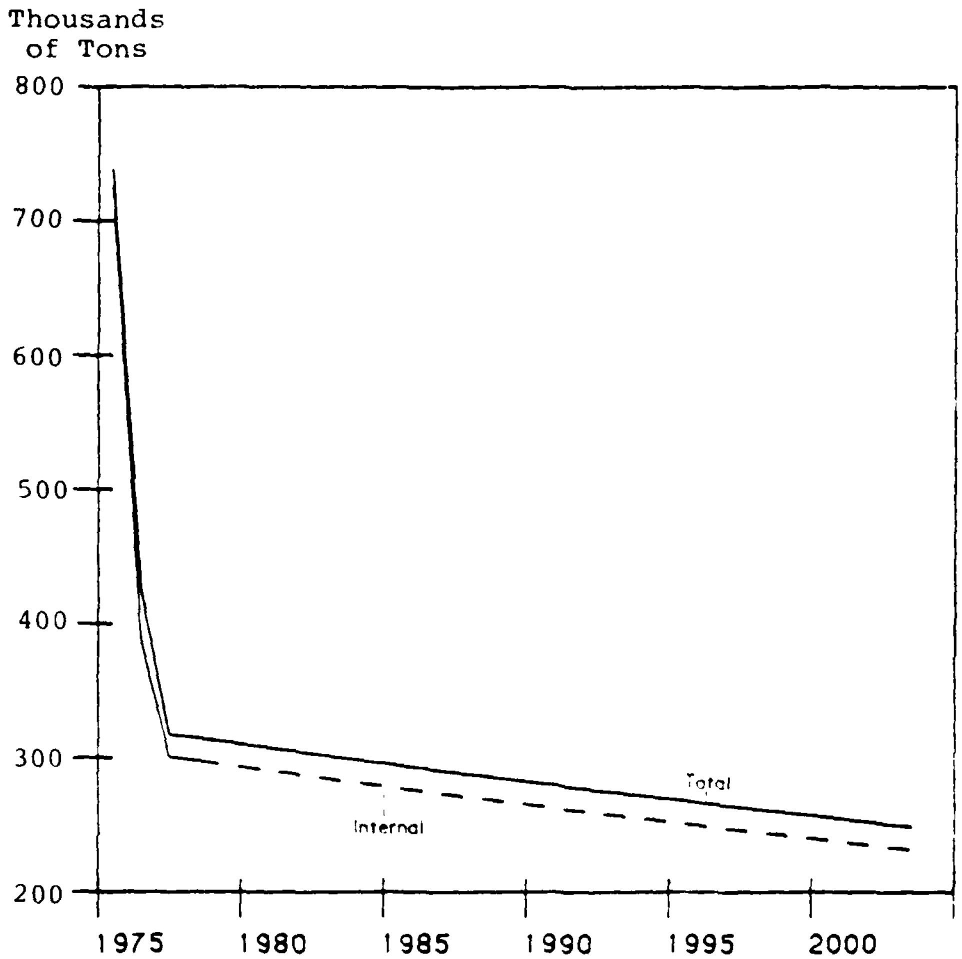
About two-thirds of the sand and gravel from this area serve as input in the concrete market while the remainder is consumed for fill sand and gravel. Sand and gravel destined for fill is easily replaced by sand and gravel from pits and quarries in the area or from limestone. The quality sand and gravel going onto concrete is a secure product as there is little or no inland production which can compete with this high-grade material.

Due to continued stringent environmental regulation and competition from quarries, DRI forecasts that Rock Island District traffic in sand and gravel will continue to decline, albeit much more slowly, through the year 2000. Although the majority of the existing barge traffic is still used in the concrete market, DRI believes that this portion of the market will stabilize over the next quarter century. Continued reduction in fill sand and gravel traffic via barge will occur at the rate of about one-half of one percent per year over the forecast period. Figure II-6 depicts the slow rate of decline in total sand and gravel movements over time, assuming no changes in the shares of within versus other district traffic.

The major alternative scenario for sand and gravel traffic in the Rock Island District would be a reversal of the current declining trend, due to a resurgence in demand for high-quality sand for concrete. During the 1969 to 1977 period, cement traffic and new construction activity have grown rapidly, while sand and gravel movements via barge have fallen dramatically. Obviously, the growth in use of sand and gravel for concrete in the Quad Cities region has come from land-based quarries. DRI judged it unlikely that substantial new river mining activity would begin and remain competitive with truck-moved sand and gravel.

Figure II-6

Rock Island District Barge Traffic - Sand, Gravel, and Crushed Rock



Source: DRI Transportation Service.

(b) Cement

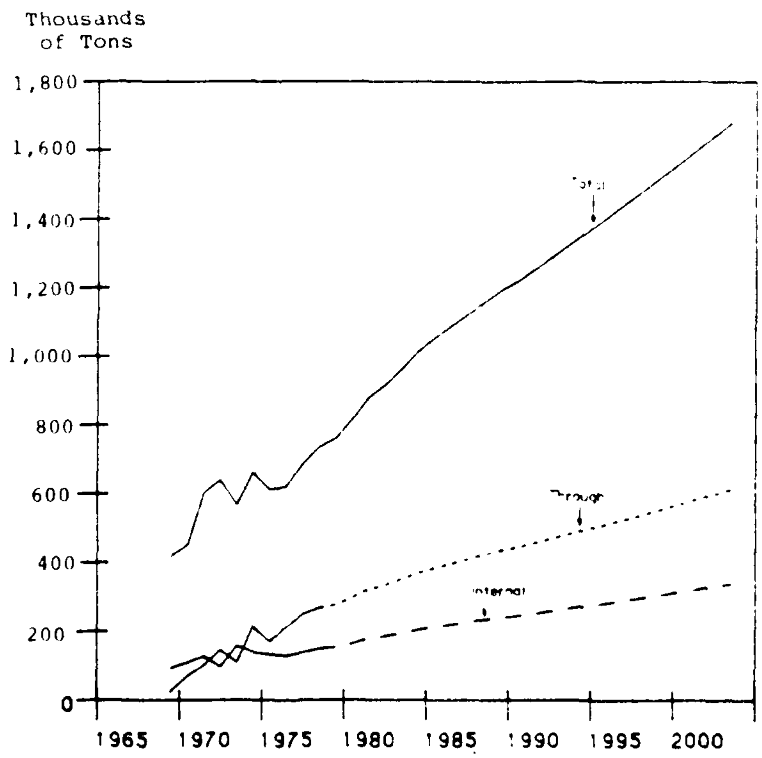
Cement has historically been produced in the lower reaches of the Rock Island District and moved by barge to destinations within and north of the district. In addition, there has been a substantial amount of through barge traffic moving to destinations in Wisconsin and Minnesota. Cement traffic has been one of the fastest growing commodity groups in the district, averaging 8% per year from 1969 to 1977.

DRI analyzed total Rock Island District barge traffic in cement and found that employment levels in Minnesota, Wisconsin, Iowa, Illinois, and Missouri explained over 90% of the historical variation in the series. Exhibit II-16 contains the final forecasting equation for Rock Island District cement traffic. The presumption is that growth in employment requires new facilities; the increase in nonresidential construction increases the demand for cement.

Figure II-7 summarizes the DRI baseline forecast for Rock Island District cement traffic via barge. Using DRI Regional Model forecasts of employment growth in the Upper Mississippi states, cement traffic via water is forecast to grow at an average annual rate of 6% per year, slightly below historical growth rates of 8% per year. As in the case of other baseline forecasts, DRI has maintained historical traffic share trends by class as well as for originating and terminating port equivalents within the Rock Island District.

Figure II-7

Rock Island District
Barge Traffic - Cement



Source: DRI Transportation Service.

OTHER COMMODITIES TRAFFIC

Although substantial in terms of total Rock Island District barge traffic, other commodity groups generally represented traffic that was quite stable over time or oriented towards special industry requirements in the Upper Mississippi River states. The four major commodities analyzed in detail were waterways improvement materials, rock salt, vegetable oils, and steel-related products. As previously mentioned, certain other small and erratic commodity flows in the Rock Island District have occurred in the past, but DRI is unable to develop any consistent forecasting methodology for projecting their movements in the future. As a result, other minor commodities were not forecast, although DRI did examine all commodity movements in the district to determine which products would be forecast.

(a) Waterways Improvement Materials

All other dredging activity within the Rock Island District is conducted by the Army Corps of Engineers as part of ongoing waterway improvement activities. The Corps uses hydraulic dredges which transport the sand and gravel slough hydraulically beyond the bank of the river. Hydraulic conveyence can move material up to one mile from the dredging site.

The Corps, in order to maintain a 300-foot wide and 11-foot deep channel, projects dredging of approximately 300,000 cubic yards of material per year. While the annual average since 1940 has been approximately 1 million cubic yards per year, Corps dredging has been declining in recent years. Although forecasting fairly constant dredging activity in the future, the Corps recognizes that this figure could vary from 0 to 2.5 million cubic yards from year to year, depending on the hydrographic cycle affecting the contour of the river bottom.

While the Corps dredging efforts at this time do not generate sand and gravel traffic for the district, there is the possibility that environmental regulations will make it necessary to barge dredged materials (as in Minnesota) to specific locations along the river so as not to endanger indigenous wildlife, upset ecosystems, or devalue private property.

(b) Rock Salt

The primary use of rock salt in the Upper Mississippi River

area is for highway ice control. In 1977, over 17 million tons of rock salt were used in the U.S., of which approximately 3% was applied in Upper Mississippi River states. In this area, almost all salt moves in by barge from the South. Due to environmental factors, salt usage per mile of highway has declined (national estimates of salt applied per lane-mile per winter have fallen from 20 to 18 tons in recent years) resulting in declining barge traffic. At the present time, about half the traffic terminates in the district and half is through traffic. The major traffic loss in the last few years has been in through movements of salt.

In evaluating potential future movements of rock salt via barge to Upper Mississippi River states, a number of factors were considered. First, possible new highway construction activity was examined. Table II-7 shows the percentage of designated interstate highway system mileage that is open to traffic in the Upper Mississippi River states. Substantially all interstate highways are currently open to traffic. Discussion with various highway department officials in these states revealed that no other major road building programs are anticipated during the forecast period. Second, projected growth in total vehicle miles traveled in the East North Central and West North Central Census Regions through the year 2003 was examined. Although substantial growth in vehicle miles traveled is expected, DRI could find no correlation between vehicle miles traveled and rock salt usage in the Upper Mississippi River states. Finally, DRI believes that environmental factors (such as groundwater pollution from salted highways) will be the primary force behind shifts in rock salt usage in these states. According to environmental groups, increased pressure from farm and community organizations is expected to steadily reduce salt application rates on Upper Mississippi River states highways.

Table II-7

1978 Interstate Highway System

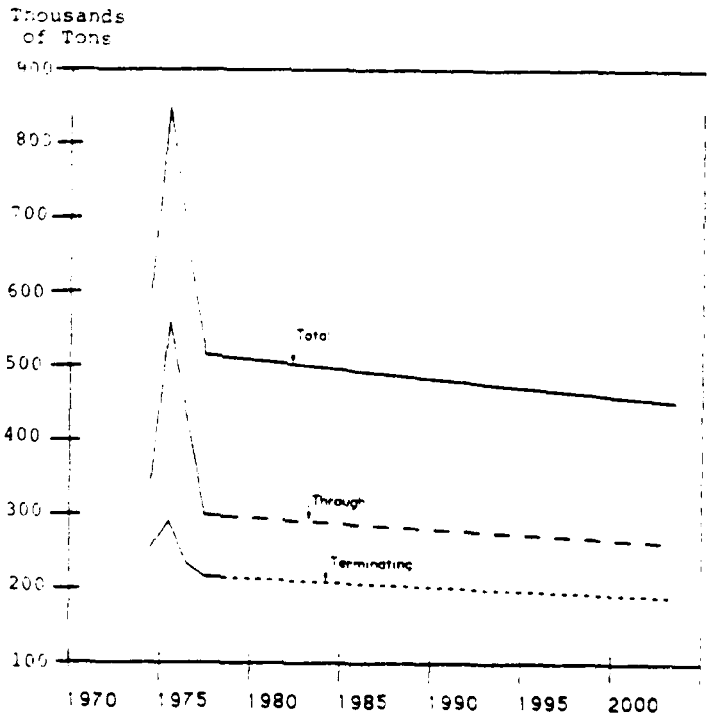
Upper River States	Designated Interstate System Mileage	Percent Open to Traffic
Minnesota	919	89.0%
Wisconsin	578	91.0
Illinois	1,723	95.0
Iowa	789	92.0
Missouri	1,147	94.0

Source: Federal Highway Administration.

Figure II-8 presents the DRI baseline forecast for rock salt barge traffic in the Rock Island District. Salt traffic is expected to decline slowly by one-half of one percent per year through the year 2003 as salt application rates decline faster than new highway construction.

Figure II-8

Rock Island District
Barge Traffic - Salt



Source: DRI Transportation Service.

(c) Vegetable Oils

The majority of vegetable oils originating in or above the Rock Island District are destined for export via Gulf ports. Shipments have grown rapidly in the past eight years, with total traffic increasing from 43,530 tons in 1969 to 207,946 tons by 1977.

DRI foresees a steady growth in the traffic through the year 2003. Using forecasts of vegetable oil exports from the DRI Agriculture Service, barge traffic in these oils via the Rock Island District is expected to double to just over 400,000 tons by the year 2003 for an average annual growth rate of 4%.

(d) Steel Products

The majority of steel-related commodities moving in the Rock Island District by barge are raw materials or semifinished forms, such as pig iron. The largest class of traffic is through traffic that is destined for facilities located north of the Rock Island District. Total traffic has almost tripled during the 1969 to 1977 period.

Using regional steel production forecasts from the DRI Steel Model, barge shipments of pig iron, coke, and ingots were projected to grow from 349,340 tons in 1977 to 666,000 tons in 2003, for an average annual growth rate of 3.6% per year.

MAJOR FINDINGS

This section is divided into three parts that summarize the results of the Rock Island District barge traffic forecast study; these parts are traffic by concept and origin/destination, traffic by commodity, and traffic density at locks.

(a) Traffic by Concept and Origin/Destination

Exhibit II-5 summarizes the Rock Island District total barge traffic forecasts by major class of traffic. Over the 1979 to 2000 forecast period, total district traffic is expected to grow at an average annual rate of 5.0%. Internal traffic is predicted to increase at an annual average rate of 1.6% per year. Total inbound traffic flows are expected to increase at the rate of 3.4% per year; outbound traffic is expected to grow twice as fast at a 6.9% rate per year. Total through traffic movements are expected to increase at an average rate per year of 4.7%.

(b) Traffic by Commodity

Exhibit II-5 details the Rock Island District barge traffic forecast by major commodity groups. In general, grains and coal

traffic experience the rapid annual growth rates, averaging 3.4% and 4.6% respectively, for the forecast period. Petroleum products are likely to grow at much lower rates than in the historical period, due to fuel substitution and increased conservation. The exception is distillate fuel oil which is expected to grow in line with the rapid increase in agricultural production. Traffic declines are expected in residual fuel oil (as utilities substitute less expensive fuels), rock salt (as environmental concerns over groundwater pollution cause a reduction in application), and sand and gravel (as competition from landside quarries increases).

(c) Traffic Density

Exhibit II-17 summarizes the estimated barge tonnage density moving through each port equivalent in the Rock Island District during the 1969 to 2001 period. Given the rapid growth in downbound grain and upbound coal and fertilizer traffic, the lower port equivalents experience more substantial traffic growth than those near the upper end of the district. For example, tonnage density increases at an average annual rate at PE 312 of 5.4% per year, more than doubling traffic passing Lock and Dam 22 by the year 2001. On the other hand, PE 334 traffic grows at the slightly slower rate of 4.6% per year to 2001.

EXHIBIT II-1

U.S. ARMY CORPS OF ENGINEERS
ROCK ISLAND DISTRICT

UPPER MISSISSIPPI RIVER PORT EQUIVALENTS

ST. PAUL DISTRICT CORPS OF ENGINEERS

Port Equivalent		River Mile Location	
Number	Name	Upstream	Downstream
360	Minneapolis Upper	857.0	853.4
358	Minneapolis Lower	853.4	847.0
356	St. Paul, Minnesota	847.0	830.0
354	L/D 2 Pool(1)	830.0	815.2
352	L/D 3 Pool	815.2	796.9
350	L/D 4 Pool	796.9	752.9
348	L/D 5 Pool	752.9	738.1
346	L/D 5a Pool	738.1	728.5
344	L/D 6 Pool	728.5	714.2
342	L/D 7 Pool	714.2	702.5
340	L/D 8 Pool	702.5	679.1
338	L/D 9 Pool	679.1	647.9
336	L/D 10 Pool	647.9	615.1

ROCK ISLAND DISTRICT CORPS OF ENGINEERS

334	L/D 11 Pool	615.1	583.0
332	L/D 12 Pool	583.0	556.7
330	L/D 13 Pool	556.7	522.5
328	L/D 14 Pool	522.5	493.2
326	L/D 15 Pool	493.2	482.9
324	L/D 16 Pool	482.9	457.1
322	L/D 17 Pool	457.1	437.1
320	L/D 18 Pool	437.1	410.5
318	L/D 19 Pool	410.5	364.2
316	L/D 20 Pool	364.2	343.2
314	L/D 21 Pool	343.2	324.9
312	L/D 22 Pool	324.9	301.2

ST. LOUIS DISTRICT CORPS OF ENGINEERS

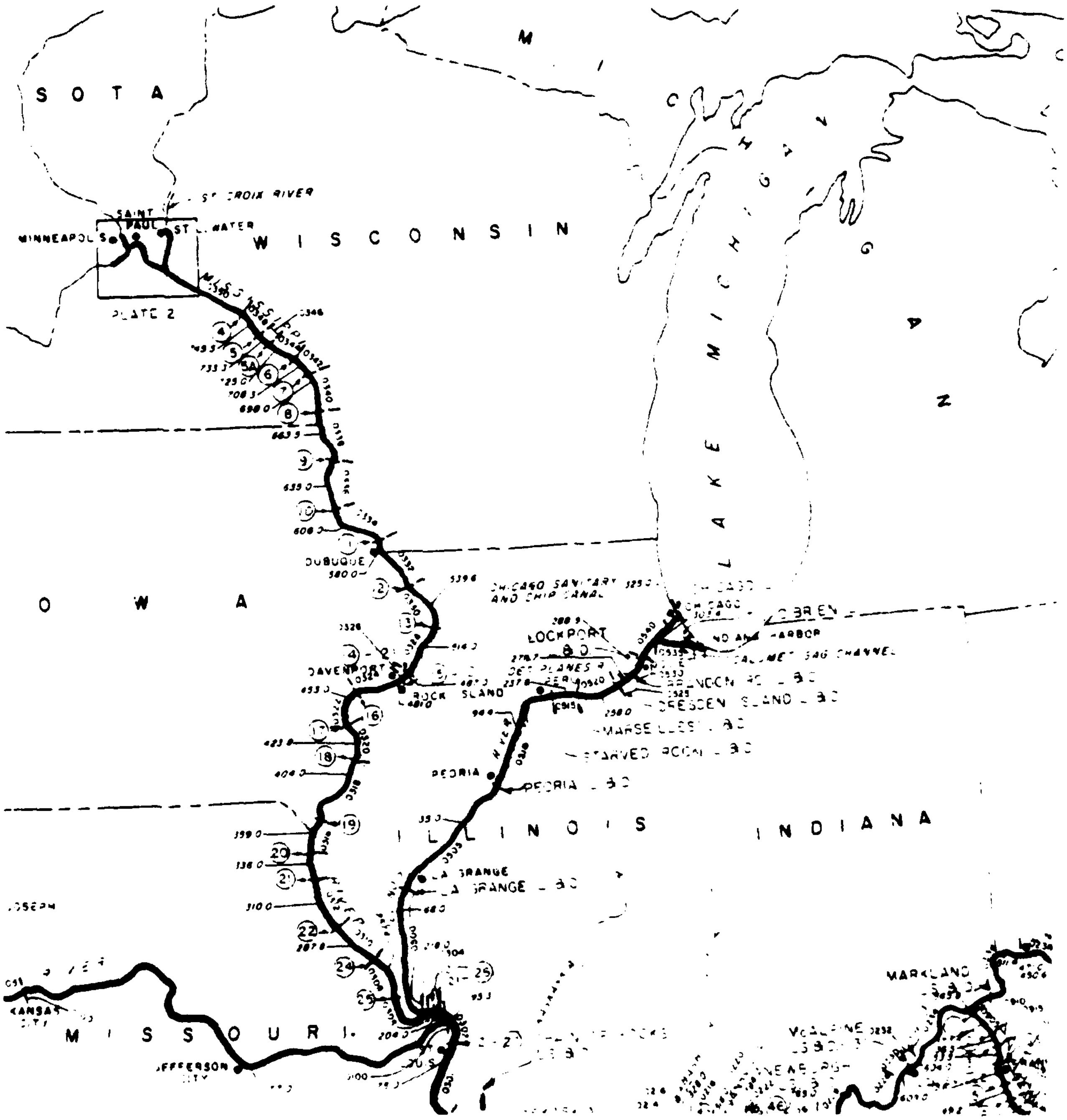
310	L/D 24 Pool	301.2	273.5
308	L/D 25 Pool	273.5	241.4
306	L/D 26 Pool	241.4	208.0

Note: (1) L/D = Lock(s) and dam.

Source: U.S. Corps of Engineers.

U.S. ARMY CORPS OF ENGINEERS
ROCK ISLAND DISTRICT

MISSISSIPPI RIVER
PORT EQUIVALENTS



Source: Corps of Engineers.

EXHIBIT II-3

U.S. ARMY CORPS OF ENGINEERS
ROCK ISLAND DISTRICT

ROCK ISLAND DISTRICT
BARGE TRAFFIC BY COMMODITY
(Tons)

COMMODITY	1969	1970	1971	1972	1973	1974	1975	1976	1977
CORN	4,087,418	4,622,344	4,128,201	5,574,157	8,468,094	8,118,256	6,971,410	8,000,176	6,621,613
WHEAT	799,083	902,811	900,955	1,259,402	966,118	1,675,516	1,819,326	1,990,755	1,919,711
SOYBEANS	1,203,094	2,591,286	2,396,013	2,280,769	1,881,001	2,700,824	1,871,335	2,536,820	2,159,725
COAL	5,619,136	6,091,631	5,928,669	6,670,752	4,567,353	4,370,044	5,086,125	4,003,893	4,721,058
SAND, GRAVEL & CRUSHED ROCK	670,264	701,965	881,315	811,287	696,850	701,511	718,336	426,190	317,042
PHOSPHATIC ROCK	245,297	397,348	513,941	641,718	595,955	681,244	555,957	330,583	496,925
ROCK SALT	659,406	677,728	606,568	771,340	554,925	692,119	840,933	664,597	515,038
OTHER GRAIN MILL PRODUCTS	77,544	86,407	97,109	197,522	250,216	516,879	565,662	901,802	910,192
VEGETABLE OILS	43,530	78,473	125,390	175,370	113,769	104,381	74,710	143,153	207,946
CHEMICALS	418,293	455,753	516,358	533,645	430,008	491,426	499,444	485,750	390,678
NITROGENOUS CHEMICAL FERTILIZERS	42,518	120,964	149,691	130,213	223,717	171,097	351,078	497,059	481,601
PHOSPHATIC CHEMICAL FERTILIZERS	127,358	187,776	167,414	82,793	52,429	56,510	158,858	81,144	108,525
OTHER FERTILIZERS	449,642	527,538	603,356	551,923	462,120	511,611	472,937	532,066	709,164
GASOLINE	1,194,885	1,390,543	1,330,436	1,191,803	955,605	1,021,446	1,009,638	712,691	745,146
JET FUEL & KEROSENE	181,704	146,270	217,182	167,688	111,827	138,760	72,889	110,483	96,288
DISTILLATE FUEL OIL	785,499	878,917	808,364	826,203	676,151	548,275	580,250	518,493	478,809
RESIDUAL FUEL OIL	104,533	9,704	40,850	41,506	55,082	104,124	132,017	46,741	188,741
LUBRICANTS	16,329	19,711	17,398	19,545	14,620	16,399	15,112	18,187	53,356
NAPTHA	15,346	21,996	37,458	21,474	20,937	17,240	18,109	35,011	21,879
ASPHALT	174,016	177,133	145,578	126,262	103,211	221,513	279,275	310,750	315,970
CRUDE PETROLEUM	0	0	0	0	0	144,418	195,294	584,246	596,027
CEMENT	419,012	452,445	602,217	639,859	567,680	661,703	610,718	621,771	687,616
PIG IRON, COKE & INGOTS	122,340	137,998	165,283	182,061	164,724	137,191	176,647	286,854	349,340
TOTAL	17,459,077	20,666,814	20,363,648	22,882,585	21,920,266	23,722,084	23,110,805	23,858,672	23,165,900

Source: DRI Transportation Service.

U.S. ARMY CORPS OF ENGINEERS
ROCK ISLAND DISTRICT

ROCK ISLAND DISTRICT
BARGE TRAFFIC BY CONCEPT
(Tons)

	1969	1970	1971	1972	1973	1974	1975	1976	1977
TOTAL TRAFFIC	17.459,077	20,666,814	20,363,648	22.882.585	21.920.266	23.722.084	23.110.805	23.858.672	23.165.900
WITHIN DISTRICT	862.128	838,049	1,044,905	940.522	830.092	873.554	892.540	537.826	494,899
INBOUND	4,165,297	4,870,739	4,733,995	5.044.375	4,285.947	4.532.259	4.771.816	4,005.531	4.635.379
UPBOUND	4,046,337	4,683,949	4,503,811	4,814.313	3.991.838	4.249.971	4.376.400	3.479.940	4.230.954
DOWNBOUND	118,960	186,790	230,184	230.062	294.109	282.288	395.416	525.591	404.425
OUTBOUND	3.112,007	3,663.512	3,750,816	4.902.944	5,477.363	6.018.544	6.493.341	7.942.509	6.987,059
UPBOUND	87,647	76.081	167,805	134.054	103,188	61.360	155.220	183.627	67,753
DOWNBOUND	3.024,360	3,590.018	3.598.609	4.783.603	5,387,111	5.962,837	6.338.121	7.762.868	6.920.796
THROUGH TRAFFIC	9.319.845	11,294,514	10,833,932	11.994.744	11,326.864	12,297,727	10.953.108	11.372.806	11,048.563
UPBOUND	5.710.392	6.179.258	6.292,342	6.788.654	4,587,651	4,675,170	5.427.453	5.632.109	6.243.662
DOWNBOUND	3.609.253	5,115.256	4,541,590	5.206.090	6,739,213	7,766,975	5.720.949	6.324.943	5.402.928
ORIGINATING ROCK ISLAND TRAFFIC									
TOTAL	3.974,135	4,501,561	4,795,721	5.843.466	6.307.455	6.892.098	7.385.881	8.480.335	7,481,958
BY PORT EQUIVALENT:									
PE314	155.742	175.913	254,089	309.148	332.996	397.074	386.837	684.746	665.701
PE316	248.063	203.547	320.161	422.492	356.202	295.219	317.507	463.621	364.718
PE318	681.507	836.308	755.448	1.133.727	1.148.998	1,192,565	1.228.557	1,442.258	1.313.819
PE320	382,036	470.505	393,886	498,779	406.787	401.559	484.092	601.385	594.583
PE322	328.721	471,408	454.431	639.104	508.494	436.525	485.043	755.573	483.828
PE324	456.816	628.298	469.356	449.040	548.890	980.660	1.323.041	1,444.723	1.195.592
PE326	93.249	85.342	187.192	178.601	233.260	425.726	222.019	197,243	174.685
PE328	990.614	934.530	1,121,361	1.194.925	1.200.963	1.225.039	1.161.326	1.174.784	1.030.229
PE330	0	0	0	0	0	0	118.800	1.273	0
PE332	50.068	50.170	75.181	139.277	693.957	651,077	670.823	735,044	713.893
PE334	0	1.295	0	3.080	1.246	21,686	35.226	57,165	39,669
TERMINATING ROCK ISLAND TRAFFIC									
TOTAL	5.027,425	5,708.788	5,778,900	5,984.897	5,116.039	5,405,813	5.664.356	4.543.357	5,130,278
BY PORT EQUIVALENT:									

	1969	1970	1971	1972	1973	1974	1975	1976	1977
PE314	371,451	404.081	403,045	404.876	295.144	357.106	301.618	345.098	337.589
PE316	112.074	57.465	22.772	23.272	8.736	21.858	20.112	23.724	43.316
PE318	373.920	598.202	666.261	813.363	748.084	746.776	776.783	590.143	690.706
PE320	0	67.630	19,300	16.300	8.700	15.900	30.100	2.600	2.550
PE322	202.695	262,437	170,247	121.221	112.959	140.345	195.947	168.442	197.965
PE324	499.463	497,847	361,717	443.526	414.509	437,070	431.739	360.029	453.986
PE326	1,348.117	1,410.927	1,781,187	1,675.391	1,370.269	1,333,174	1,250.219	879.405	869.253
PE328	721.084	794.377	727,339	[illegible]	585.238	647.957	893.761	788.082	923.287
PE330	0	0	0	0	0	0	5.060	5.000	10.000
PE332	573.824	671.935	713.816	[illegible]	713.243	727.135	749.440	665.218	819.535
PE334	596.857	724.583	635.964	[illegible]	671.363	712.873	682.128	608.245	641.642

Source: DRI Transportation Service.

U.S. ARMY CORPS OF ENGINEERS
ROCK ISLAND DISTRICT

ROCK ISLAND DISTRICT
BARGE TRAFFIC BY CONCEPT

BASELINE FORECAST
(Tons)

	1975	1976	1977	1978	1979	1980	1981	1982	1983
TOTAL TRAFFIC	23,110,805	23,858,872	23,165,900	25,073,948	25,783,754	26,745,731	28,031,997	29,129,543	30,330,782
WITHIN DISTRICT	892,540	537,826	494,899	499,929	507,052	518,332	531,712	540,065	550,016
INBOUND	4,771,816	4,005,531	4,635,379	4,582,275	4,923,251	5,042,685	5,382,818	5,710,704	5,919,965
UPBOUND	4,376,400	3,479,940	4,230,954	4,183,056	4,491,979	4,599,847	4,905,602	5,207,666	5,393,695
DOWNBOUND	395,416	525,591	404,425	399,219	431,272	442,838	477,215	503,038	525,270
OUTBOUND	6,493,341	7,942,509	6,987,059	7,932,473	8,247,561	8,607,070	8,949,090	9,234,580	9,643,511
UPBOUND	155,220	183,627	67,753	63,900	69,047	71,364	73,917	77,621	80,567
DOWNBOUND	6,330,121	7,762,868	6,920,796	7,868,574	8,178,514	8,535,706	8,875,173	9,156,959	9,562,944
THROUGH TRAFFIC	10,953,108	11,372,806	11,048,563	12,059,271	12,105,791	12,577,644	13,171,377	13,644,195	14,218,290
UPBOUND	5,427,453	5,632,109	6,243,662	6,227,173	6,580,494	6,727,427	7,093,345	7,307,355	7,566,063
DOWNBOUND	5,720,949	6,324,943	5,402,928	6,461,241	6,151,050	6,472,541	6,639,708	6,948,562	7,257,200

	1984	1985	1986	1987	1988	1989	1990	1991	1992
TOTAL TRAFFIC	31,313,769	32,323,985	33,477,409	34,372,185	35,649,435	37,083,148	38,669,182	39,898,662	41,279,309
WITHIN DISTRICT	550,172	566,120	570,612	576,001	584,590	592,654	598,865	605,719	612,725
INBOUND	6,100,640	6,293,525	6,439,773	6,628,355	6,872,648	7,093,134	7,252,295	7,556,416	7,791,989
UPBOUND	5,552,311	5,723,773	5,849,431	6,013,709	6,230,721	6,427,297	6,564,134	6,834,036	7,038,908
DOWNBOUND	548,329	569,753	590,342	614,646	641,927	665,837	695,162	722,380	753,081
OUTBOUND	9,940,580	10,271,320	10,759,944	11,051,338	11,486,514	12,069,923	12,662,220	13,116,594	13,592,589
UPBOUND	80,354	82,226	81,981	82,029	85,095	88,799	91,461	93,269	95,049
DOWNBOUND	9,860,226	10,189,094	10,677,963	10,969,309	11,403,419	11,981,125	12,570,759	13,023,325	13,497,540
THROUGH TRAFFIC	14,714,377	15,193,019	15,707,080	16,116,491	16,703,683	17,327,436	18,045,802	18,619,933	19,292,006
UPBOUND	7,799,286	8,086,750	8,280,771	8,517,220	8,830,190	9,111,165	9,479,374	9,752,468	10,099,265
DOWNBOUND	7,514,322	7,726,170	8,039,794	8,206,612	8,474,963	8,812,135	9,150,579	9,463,817	9,781,574

	1993	1994	1995	1996	1997	1998	1999	2000	2001
TOTAL TRAFFIC	42,252,362	43,312,821	44,272,637	45,399,802	46,499,215	47,646,029	48,795,969	49,580,820	51,195,668
WITHIN DISTRICT	619,658	626,777	631,070	641,636	649,248	657,263	665,225	573,241	581,558
INBOUND	7,865,265	7,951,845	7,991,046	8,095,527	8,171,663	8,253,880	8,320,814	8,395,348	8,467,601
UPBOUND	7,103,586	7,179,455	7,217,300	7,306,932	7,374,267	7,446,371	7,505,462	7,572,659	7,635,161
DOWNBOUND	761,679	772,390	775,746	788,595	797,596	807,509	815,352	824,189	832,441
OUTBOUND	14,078,085	14,579,401	15,093,027	15,629,893	16,181,792	16,752,232	17,345,400	17,959,649	18,597,143
UPBOUND	96,741	98,474	100,285	102,194	104,021	105,909	107,925	139,824	111,795
DOWNBOUND	13,981,344	14,480,928	14,995,742	15,527,699	16,077,772	16,647,323	17,237,575	17,849,825	18,485,348
THROUGH TRAFFIC	19,897,354	20,154,798	20,546,494	21,032,745	21,495,413	21,981,854	22,454,720	22,951,081	23,449,366
UPBOUND	10,202,449	10,339,092	10,404,675	10,555,841	10,675,047	10,805,709	10,912,779	11,021,480	11,135,862
DOWNBOUND	10,102,121	10,431,204	10,787,864	11,113,759	11,465,289	11,835,394	12,212,769	12,602,260	13,004,613

ROCK ISLAND DISTRICT
BARGE TRAFFIC BY COMMODITY

BASELINE FORECAST (Cont'd.)
(Tons)

COMMODITY	1975	1976	1977	1978	1979	1980	1981	1982
CORN	6 971 410	4 033 176	6 823 [illegible]	[illegible] 499	[illegible]	[illegible] 142	6 284 858	6 410 276
WHEAT	1 814 126	1 942 785	1 949 [illegible]	1 969 437	2 [illegible]	[illegible]	2 22[illegible]	[illegible] 337 486
SOYBEANS	1 87[illegible] 135	2 516 420	2 [illegible] 725	3 [illegible] 6 844	2 [illegible]	2 871 172	3 [illegible] 583	3 289 329
COAL	5 088 125	4 331 493	4 721 156	4 603 750	5 [illegible]	5 197 938	5 602 122	5 807 323
SAND GRAVEL & CRUSHED ROCK	118 136	426 130	3 [illegible] 142	3 [illegible] 466	3[illegible] 182	379 547	325 621	302 745
PHOSPHATIC ROCK	555 157	338 193	495 125	551 100	552 [illegible]	660 100	551 100	557 400
ROCK SALT	843 133	564 597	515 138	4[illegible] 463	574 [illegible]	477 351	524 414	512 290
OTHER GRAIN MILL PRODUCTS	565 002	306 302	944 132	1 [illegible] 325	1 262 [illegible]	1 240 274	1 359 [illegible]5	1 313 877
VEGETABLE OILS	72 110	143 153	207 146	74 739	[illegible] 122	176 123	182 479	[illegible] 84
CHEMICALS	493 134	485 150	390 178	344 133	179 [illegible]	388 123	421 135	427 460
NITROGENOUS CHEMICAL FERTILIZERS	351 178	497 159	484 401	452 585	493 122	511 254	533 252	981 723
PHOSPHATIC CHEMICAL FERTILIZERS	158 858	81 144	128 525	104 680	111 589	115 986	743 635	127 279
OTHER FERTILIZERS	472 937	532 066	709 64	511 240	729 555	753 400	783 444	826 609
GASOLINE	1,009 618	712 691	745 148	1 6 442	789 305	792 135	654 438	978 418
JET FUEL & KEROSENE	72 989	118 483	96 248	125 646	[illegible] 287	[illegible]	124 462	130 401
DISTILLATE FUEL OIL	580 150	518 493	478 309	478 169	537 [illegible]	5[illegible] 242	654 490	770 499
RESIDUAL FUEL OIL	132 217	46 741	188 741	114 381	160 752	43 221	166 427	167 [illegible]4
LUBRICANTS	5 112	8 87	53 356	53 138	54 [illegible]	55 119	57 258	58 426
NAPHTHA	8 109	38 241	21 479	22 390	23 120	23 148	24 398	25 140
ASPHALT	270 275	312 750	315 970	324 817	332 312	343 262	352 873	362 793
CRUDE PETROLEUM	195 294	584 248	598 127	829 143	625 754	422 124	621 676	512 327
CEMENT	812 718	821 771	647 318	736 433	78 [illegible]35	911 335	862 405	917 94
PIG IRON, COKE & INGOTS	176 647	286 854	349 340	176 338	395 408	407 270	418 874	420 34
TOTAL	23,110,805	23,858,672	23,165,900	25,373,948	25,783,754	26 745 731	28,334 897	2[illegible],129,543

COMMODITY	1983	1984	1985	1986	1987	1988	1989	1990
CORN	8,995 994	9 315 937	9 47[illegible] 172	10 334 430	10 483 932	[illegible]80[illegible] 393	11,585 994	11,992 332
WHEAT	2,458 523	2 570 312	2 658 178	2 733 208	2 191 [illegible]9	2 858 344	2 933 883	3,043 669
SOYBEANS	3,166 426	3 245 [illegible]	3 332 145	3 221 589	3 [illegible]	3 [illegible]9	2 944 [illegible]8	3,034,072
COAL	6,128 890	6,456 26[illegible]	6 756 [illegible]	[illegible] 351 928	[illegible] 425 783	[illegible] 44	8,[illegible] 978	8,673 62
SAND GRAVEL & CRUSHED ROCK	299 887	297 059	294 158	233 185	288 [illegible]	266 123	242 223	280 670
PHOSPHATIC ROCK	550 300	557 300	550 [illegible]	550 102	552 [illegible]	552 [illegible]	553 303	553 303
ROCK SALT	499 119	497 280	494 133	492 319	343 56	487 [illegible]	344 472	482 547
OTHER GRAIN MILL PRODUCTS	1,475 114	1 437 122	1 613 241	1 814 90	1 956 [illegible]	2 152 [illegible]	2 4[illegible] 354	2 725 528
VEGETABLE OILS	184 461	191 233	197 272	227 368	219 287	231 [illegible]6	255 349	281 48
CHEMICALS	427 194	426 540	444 232	444 125	444 [illegible]	46 [illegible]3	48 268	499 280
NITROGENOUS CHEMICAL FERTILIZERS	585 54	583 182	538 55	536 426	538 782	42 [illegible]	553 631	671 805
PHOSPHATIC CHEMICAL FERTILIZERS	122 677	132 446	15 143	36 672	136 [illegible]	[illegible] 409	148 583	51 383
OTHER FERTILIZERS	461 48	859 383	881 173	673 181	69 [illegible]4	[illegible] 452	981 333	992 534
GASOLINE	970 140	965 170	956 273	348 444	942 37	337 44	935 825	937 79
JET FUEL & KEROSENE	120 105	33 893	135 573	128 8[illegible]	4[illegible]	[illegible] 424	148 25	148 229
DISTILLATE FUEL OIL	813 464	8[illegible]	337 123	375 445	1 231 [illegible]3	[illegible] 135	1 [illegible] 949	1 147 788
RESIDUAL FUEL OIL	111 419	[illegible] 128	181 43	119 936	79 [illegible]	82 147	195 368	187 226
LUBRICANTS	53 428	61 284	42 714	44 240	65 [illegible]	[illegible] 343	18 9[illegible]	72 632
NAPHTHA	25 348	26 733	27 43	28 649	29 [illegible]	[illegible] 142	[illegible] 689	33 128
ASPHALT	372 310	383 352	394 46	405 22	416 464	428 25	440 [illegible]2	452 439
CRUDE PETROLEUM	604 312	599 231	579 101	613 485	607 341	82 469	595 884	594 151
CEMENT	963 417	313 330	1 354 82	1 248 127	1 123 390	[illegible] 178	1 193 581	1 219 589
PIG IRON, COKE & INGOTS	438 322	450 720	465 594	478 333	464 878	495 158	505 459	5 5 358
TOTAL	30,330,782	31 313 768	32,323,949	33,477 409	34,372 [illegible]85	35 549 435	37 283 148	38,669,182

COMMODITY	1991	1992	1993	1994	1995	1996	1997	1998
CORN	12,384 229	12 755 841	13 188 988	13 578 850	13 993 3[illegible]	14 422 282	14 856 879	15 324 338
WHEAT	3,143,125	3 252 935	3 356 470	3 448 958	3 54[illegible]	3 646 499	3 5[illegible] 234	3 931 924
SOYBEANS	3,101 329	3 187 884	3 205 773	3 124 320	3 379 552	[illegible]	3 52 92	3,536 137
COAL	9 032 128	9,519 335	9 587 319	9 544 [illegible]	9 685 425	3 475 122	9 873 581	9 960 238
SAND GRAVEL & CRUSHED ROCK	278 333	279 423	[illegible]	[illegible] 282	247 [illegible]	275 240	282 797	2[illegible] 330
PHOSPHATIC ROCK	550 300	550 300	557 [illegible]	551 [illegible]	65 [illegible]	4[illegible]	553 300	5[illegible] 330
ROCK SALT	480 134	477 733	479 145	472 368	47[illegible]	444 250	465 309	[illegible] 579
OTHER GRAIN MILL PRODUCTS	2 904 298	3 292 598	3 291 323	3 52[illegible] 433	3 722 [illegible]	3 364 294	4 202 9[illegible]	4 442 283
VEGETABLE OILS	292 134	301 865	319 988	328 392	341 44	[illegible]	344 146	382 514
CHEMICALS	514 199	8[illegible] 392	523 410	532 447	542 [illegible]	442 181	562 2[illegible]8	572 298
NITROGENOUS CHEMICAL FERTILIZERS	438 47	770 351	[illegible] 428	727 589	72 [illegible] 233	[illegible] 81	[illegible] 707	[illegible] 32
PHOSPHATIC CHEMICAL FERTILIZERS	46 100	[illegible] 144	41 4	167 205	[illegible] 538	[illegible]	[illegible] 440	[illegible] 854
OTHER FERTILIZERS	[illegible] 279	1 236 [illegible]	5A 5	1 [illegible] 412	1 293 988	[illegible]	1 45 928	1 48 [illegible]
GASOLINE	941 152	145 148	453 119	56 454	975 359	[illegible] 3	848 385	837 186
JET FUEL & KEROSENE	43 [illegible]	5 4	52 15	83 343	195 243	64 [illegible]2	4 [illegible]25	19 899
DISTILLATE FUEL OIL	[illegible]4	1 146 421	22[illegible]	1 2[illegible] 315	42 [illegible]	1 239 494	1 251 440	1 287 338
RESIDUAL FUEL OIL	82 42	[illegible] 216	66 139	162 442	74 [illegible]	81 [illegible]	92 102	[illegible] 592
LUBRICANTS	12 27	14 143	18 [illegible]	[illegible]	13 [illegible]28	4[illegible] 433	63 388	45 389
NAPHTHA	14 [illegible]	18 778	[illegible]	78 778	47 453	[illegible] 214	44 388	46 781
ASPHALT	465 23	479 26	43[illegible] 4	1 5 278	5[illegible] 124	5[illegible] 368	940 819	944 289
CRUDE PETROLEUM	596 153	458 333	475 [illegible]5	4 4 298	526 [illegible]5	4 4 484	5[illegible] 423	659 249
CEMENT	292 39	284 90	1 342 43	354 289	288 47[illegible]	423 853	1 459 222	1 494 877
PIG IRON, COKE & INGOTS	525 159	535 467	546 134	487 4 6	566 566	562 339	54 440	933,473
TOTAL	3[illegible] 898 462	4[illegible] 279 339	42 282 362	43 3[illegible]2 821	44 273 [illegible]37	45 299 802	46 490 318	47 848 329

ROCK ISLAND DISTRICT
BARGE TRAFFIC BY COMMODITY

BASELINE FORECAST (Cont'd.)
(Tons)

COMMODITY	1999	2000	2001
CORN	15,754,280	6,237,935	16,729,162
WHEAT	4,361,408	4,189,839	4,322,159
SOYBEANS	3,672,592	3,750,575	3,830,[illegible]8
COAL	10,324,136	10,35[illegible],992	10,[illegible]36,[illegible]2
SAND GRAVEL &CRUSHED ROCK	257,367	255,154	253,173
PHOSPHATIC ROCK	550,000	550,000	550,000
ROCK SALT	491,261	494,355	496,450
OTHER GRAIN & MILL PRODUCTS	4,739,695	5,024,287	5,327,408
VEGETABLE OILS	399,420	414,[illegible]	431,[illegible]4
CHEMICALS	582,490	591,[illegible]57	603,160
NITROGENOUS CHEMICAL FERTILIZERS	801,368	817,472	833,144
PHOSPHATIC CHEMICAL FERTILIZERS	145,218	14[illegible],260	143,[illegible]5
OTHER FERTILIZERS	1,192,343	1,216,[illegible]7	1,243,[illegible]2
GASOLINE	1,207,930	[illegible],869	1,228,[illegible]4
JET FUEL & KEROSENE	160,325	161,[illegible]3	162,[illegible]9
DISTILLATE FUEL OIL	1,272,349	1,282,379	1,293,454
RESIDUAL FUEL OIL	146,154	145,379	143,394
LUBRICANTS	47,438	49,537	[illegible]1,[illegible]66
NAPTHA	46,203	50,450	52,464
ASPHALT	580,789	596,[illegible]	61[illegible],[illegible]28
CRUDE PETROLEUM	670,328	682,659	69[illegible],[illegible]9
CEMENT	1,531,[illegible]27	1,567,574	1,604,[illegible]23
PIG IRON,COKE&INGOTS	615,542	627,853	640,[illegible]
TOTAL	48,795,969	49,980,820	51,[illegible]95,668

Source: DRI Transportation Service.

U.S. ARMY CORPS OF ENGINEERS
ROCK ISLAND DISTRICT

ROCK ISLAND DISTRICT COAL TRAFFIC
(Tons)

SCENARIO - HISTORICAL

	1969	1970	1971	1972	1973	1974	1975	1976	1977
Total Traffic	5,619,136	6,081,631	5,928,669	6,670,752	4,567,353	4,370,094	5,091,760	4,005,306	4,721,058
Within District	36,154	0	0	0	0	0	2,759	6,957	1,362
Inbound	1,660,527	1,837,683	1,574,305	1,872,895	1,565,200	1,717,200	1,898,817	1,488,809	1,849,497
Upbound	1,660,527	1,833,719	1,569,946	1,857,691	1,523,936	1,682,030	1,713,672	1,147,783	1,597,076
Downbound	0	3,964	4,359	15,204	41,264	35,170	185,145	341,026	252,421
Outbound	5,743	4,022	0	0	0	8,943	5,635	1,413	0
Upbound	1,374	4,022	0	0	0	0	0	0	0
Downbound	4,369	0	0	0	0	8,943	5,635	1,413	0
Through Traffic	3,916,712	4,239,926	4,354,364	4,797,857	3,002,153	2,643,951	3,184,549	2,508,127	2,870,199
Upbound	3,916,712	4,239,926	4,354,364	4,795,189	3,000,775	2,590,841	2,987,616	2,505,320	2,865,806
Downbound	0	0	0	2,668	1,378	53,110	196,933	2,807	4,393

Source: DPI Transportation Service.

EXHIBIT II-6

U.S. ARMY CORPS OF ENGINEERS
ROCK ISLAND DISTRICT

1977 UTILITIES WITH WATERBORNE FUEL DELIVERY
UPPER MISSISSIPPI RIVER - MINNEAPOLIS TO MOUTH OF MISSOURI RIVER

PE	Company, Plant and State	KWH Production (million)	Total Coal Usage (000's)	% Coal	Coal Sources and Quantities (000's) Delivered: Montana	Illinois	West Kentucky	Wyoming	Virginia	East Kentucky	Indiana	Other	% Water Delivered
	Northern States Power (MN)												
356	High Bridge	1315	838	.98	494.0	115.0							.15
358	Black Dog	1285	774	.99	649.0	263.0	17.0						1.00
352	Allan King	2932	1531	1.00	884.0	463.0							.99
	Dairyland Power Coop (WS)												
340	Alma	1024	628	1.00	198.5	157.6	94.8				12.9		1.00
338	Genoa	2066	1011	1.00	234.2	236.6	230.0				31.0		1.00
334	Stoneman	213	129	1.00		142.1	3.1				2.9		1.00
	Interstate Power Co. (IA)												
330	Lansing	1091	730	.99	24.1	163.0		900.2					1.00
	Wisconsin Power & Light (WS)												
334	Nelson Dewey	1187	578	1.00	135.7	357.5							1.00
	Interstate Power Co. (IA)												
332	Dubuque	283	169	.87	42.3	168.3	28.6						1.00
328	Milton Kapp	906	473	.99	93.2	363.1	70.2	2.7		6.1			.75
	Eastern Iowa Light (IA)												
324	Montpelier		(not operating)										
322	Muscatine	446	225	1.00		250.9	55.3						.75
	Union Electric (MS)												
301	Meramec	3732	1757	.99		848.0	59.0		442.0	231.0	57.0	75.0	1.00
	Total Burn		8873										
	Total Delivered		8601.9		2755.0	3528.1	558.0	902.9	442.0	237.1	103.8	75.0	
	Coal Origins as % of Total Delivered				.32	.41	.06	.10	.05	.03	.01	.01	

Source: National Coal Association, Steam Electric Plant Factors, 1977.

EXHIBIT II-7

EXHIBIT II-8

U.S. ARMY CORPS OF ENGINEERS
ROCK ISLAND DISTRICT

1977-1986 WATER SERVED UTILITY
NEW COAL DEMANDS AND NEW PLANTS

UPPER MISSISSIPPI RIVER

State	Utility and Plant	Coal Source (BOM District)	MO/YR On Stream	1981 Coal Demand (000's)	1986 Coal Demand (000's)
Wisconsin	Dairyland Power Coop - Alma	19 (Wyoming) rail to Minneapolis water to Alma	5/79	1000	1000
Minnesota	Northern States Power - Becker (Sherbur ne City)	19 22 (Montana/Wyoming) on BN	6/77 5/81 5/83	4700	7200
Iowa	Muscatine Municipal - Muscatine	22 (via rail)	6/82	-	450
Iowa	Interstate Power - Lansing	19 (Wyoming) rail to Minneapolis water to Lansing	6/77	800	800
Missouri	Union Electric - Rush Island (Crystal City, below Missouri River) PE301	10, 15 (barge)	1/17	1400	1250

Source: U.S. Department of Energy, Status Of Coal Supply Contracts For New Electric Generating Units, 1977-1986, First Annual Supplement. May 1978.

EXHIBIT II-9

U.S. ARMY CORPS OF ENGINEERS
ROCK ISLAND DISTRICT

UPPER MISSISSIPPI WATERBORNE COAL TRAFFIC EQUATION

Ordinary Least Squares

Annual (1965 to 1977) 13 Observations
Dependent Variable: NTT[illegible]21UMDEST

	Coefficient	Std. Error	T-Stat	Independent Variable
	-1.32889E+06	6.327E+05	-2.[illegible]00	Constant
1)	+8.3280	4.030	2.[illegible]2	DBITLIGTOT@WNC-DBITLIGUE@ENC
2)	-1.68820E+06	2.798E+05	-6.030	DMYWTHR
3)	-2.[illegible]9796E+06	4.320E+05	-5.088	MKTSHR(1:2)

R-Bar Squared: 0.9286
Durbin-Watson Statistic: 2.[illegible]357
Standard Error of the Regression: 3.478E+05 Normalized: 0.05658
F-Statistic (3,9): 53.03

	Partial Correlation	Mean	Standard Deviation	Elasticity at Mean
1) DBITLIGTOT@WNC-DBITLIGUE@ENC	0.970683	61394	28762.3	.28593
2) DMYWTHR	-0.895400	0.[illegible]53846	0.360801	-0.0422502
3) MKTSHAR(1:2)	-0.861[illegible]0	0.076923[illegible]	0.266469	-0.0275036

* Marks Actual Values

Date	Actual	Fitted
1965	4,[illegible]82,985	4,374,072
1966	4,307,231	4,360,399
1967	5,476,[illegible]57	5,259,519
1968	5,[illegible]96,[illegible]2	5,394,675
1969	5,6[illegible]7,088	5,[illegible]3,[illegible]90
1970	6,209,494	6,420,405
1971	6,034,358	6,[illegible]53,673
1972	7,0[illegible]7,758	7,094,67[illegible]
1973	5,[illegible]3,568	5,398,[illegible]54
1974	5,[illegible]21,058	5,495,372
1975	8,795,9[illegible]3	8,[illegible]04,512
1976	8,256,951	8,[illegible]4,[illegible]49
1977	6,324,639	6,324,639

where NTT[illegible]21UMDEST = Upper Mississippi Waterborne Coal Tonnage

DBITLIGTOT@WNC = Demand for Bituminous Coal and Lignite in the West North Central Region, Total

DBITLIGEU@ENC = Demand for Bituminous Coal and Lignite in the East North Central Region, Electric Utilities

DMYWTHR = Dummy for Weather Problems in 1973 and 1974

MKTSHR(1:2) = Market Share of Model Traffic, Rail versus Barge in the Upper Mississippi River

Source: DRI Transportation Service.

EXHIBIT II-10

U.S. ARMY CORPS OF ENGINEERS
ROCK ISLAND DISTRICT

PROJECTED COAL DEMAND BY MAJOR SECTOR
DRI/CONTROL0579
(Million Short Tons)

	1978	1980	1985	1990	1995	2000	2003	% Change 1978-1980	% Change 1980-1990	% Change 1990-2003
Electric Utilities	486.6	535.0	696.3	901.6	1,146.9	1,335.0	1,445.4	4.9	5.3	3.7
Industrial - Steam	55.3	73.6	101.2	141.3	178.5	234.1	279.7	15.2	6.8	5.4
- Coking	75.0	79.0	89.6	97.7	109.0	119.5	127.0	2.6	2.1	2.0
Household and Commercial	7.5	8.1	9.5	11.2	13.0	15.1	16.5	3.9	3.3	3.0
Synthetic Fuel	0.0	0.0	4.5	15.0	22.5	30.0	35.0	0.0	NC	6.7
Exports	39.8	60.6	74.0	81.0	88.6	97.0	102.4	23.3	2.9	1.8
TOTAL CONSUMPTION	664.2	756.1	975.1	1,247.8	1,558.5	1,830.7	2,006.0	6.7	5.1	3.7

Source: DRI Transportation Service.

EXHIBIT II-11

U.S. ARMY CORPS OF ENGINEERS
ROCK ISLAND DISTRICT

PROJECTED ENERGY DEMANDS FOR THE EAST NORTH CENTRAL REGION (8)

	YEARS								[illegible]	[illegible]
	1978	1979	1980	1985	1990	1995	2000	2003	78 TO 90	90 TO 03
MOTOR GASOLINE (millions of gallons)	20,356.2	21,254.7	21,310.4	18,458.5	16,498.0	16,477.0	17,036.2	17,370.0	-2.0	0.5
ELECTRICITY (billion kwh)										
Demands										
Residential	116.5	123.5	128.5	154.1	200.6	225.0	239.7	245.2	4.5	1.5
Commercial	90.5	91.4	92.1	108.2	121.5	123.8	129.7	133.0	2.5	0.7
Industrial	170.4	164.3	165.7	224.7	289.7	359.1	405.5	427.7	4.5	3.0
Transportation	0.4	0.4	0.4	0.4	0.5	0.6	0.6	0.7	2.1	2.5
Interdepartmental	0.3	0.3	0.4	0.7	1.0	1.4	1.6	1.7	10.3	3.3
Total	378.1	380.5	387.1	498.1	613.4	710.9	777.1	808.4	4.1	2.1
Generation	384.3	403.0	409.9	527.5	649.5	752.8	823.0	856.1	4.5	2.1
Gen. to Demand Ratio	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.0	0.0
Generating Capacities (thousand megawatts)										
Coal	76.4	77.2	78.0	84.1	92.7	99.2	106.1	111.1	1.8	2.2
Oil	13.6	15.5	15.0	14.0	12.3	11.7	11.6	11.0	-0.5	-1.2
Natural Gas	1.4	1.4	1.4	1.5	1.4	1.3	1.2	1.0	-0.2	-2.3
Nuclear	11.0	11.0	12.9	24.5	27.1	34.9	39.1	41.3	7.8	3.4
Hydro	2.8	3.2	3.2	3.2	3.2	3.2	3.2	3.2	[illegible]	0.0
Solar	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	NC	8.6
Exotic	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	NC	NC
Total	105.2	108.4	111.2	127.2	129.2	150.0	161.2	168.0	1.7	2.1
UTILITY FUELS (trillion btu)										
Coal	3,121.5	3,256.0	3,385.5	4,037.5	5,003.0	5,305.1	5,258.7	5,454.5	4.0	2.0
Fuel Oil	270.5	138.5	124.3	90.1	104.3	0.0	0.0	0.0	-7.5	-100.0
Natural Gas	28.9	27.3	26.7	22.0	19.0	19.0	19.0	19.0	-3.4	0.0
Nuclear	504.5	544.9	704.1	1,227.0	1,545.2	2,037.3	2,224.0	2,477.4	8.7	2.2
Hydropower	44.3	71.2	71.2	71.2	71.2	71.2	71.2	71.2	4.0	0.0
NATURAL GAS (trillion btu)										
Demands										
Residential	1,558.0	1,593.2	1,629.9	1,759.5	1,894.2	1,950.2	1,978.1	1,991.8	1.5	0.4
Commercial	758.5	768.2	775.4	828.9	843.5	855.2	859.5	872.8	0.9	0.2
Industrial	1,486.2	1,575.2	1,410.1	1,089.5	1,184.1	984.6	827.5	752.7	-1.9	-3.4
Total	3,802.8	3,936.7	3,815.5	3,677.9	3,921.9	3,790.0	3,666.0	3,617.2	0.2	-0.6
Natural Gas Availability	3,857.7	3,954.5	3,843.2	3,699.9	3,940.9	3,809.0	3,685.0	3,636.0	0.2	-0.6
PRICES										
Marginal Residential Elec. (1)	3.6	3.9	4.0	5.6	6.9	9.1	12.4	15.2	5.7	6.2
Average Commercial Elec. (1)	4.1	4.6	5.1	[illegible]	9.0	12.0	[illegible]	[illegible]	6.9	6.3
Average Industrial Elec. (1)	2.6	3.1	3.5	5.0	6.5	9.0	12.3	15.0	7.3	[illegible]
Average Residential Gas (2)	25.2	29.5	31.5	52.5	98.3	183.8	256.1	334.9	[illegible]	9.8
Average Commercial Gas (2)	24.2	27.4	29.0	51.2	96.2	161.1	253.1	331.8	12.2	[illegible]
Average Industrial Gas (2)	22.0	25.1	30.5	59.0	93.7	158.4	250.0	328.3	12.8	[illegible]
Coal - Electric Utilities (3)	[illegible]	[illegible]	1.4	[illegible]	[illegible]	5.2	7.5	9.6	9.9	8.1
Oil - Electric Utilities (3)	2.4	3.0	3.4	6.2	9.0	15.1	[illegible]	32.2	[illegible]	[illegible]
Natural Gas - Elec. Util. (3)	1.9	2.1	2.3	5.0	8.0	13.6	21.5	28.0	12.8	[illegible]
ECONOMIC INDICATORS										
Residential Population (4)	42.2	42.7	43.3	44.6	45.4	45.8	45.9	45.8	0.6	0.1
Disposable Income (5)	258.2	323.8	359.8	573.1	946.4	1,228.0	1,710.9	2,104.0	9.4	[illegible]
Commercial Employment (6)	9,754.5	9,936.0	10,388.3	11,361.1	11,543.1	11,755.2	11,805.1	11,895.9	1.4	0.2
Housing Stock (7)	14,285.6	14,496.1	14,535.5	15,764.4	16,793.9	17,264.7	17,242.5	17,147.6	1.4	0.2
% Elec. Heated	9.7	10.0	10.7	13.8	[illegible]	19.6	21.5	22.6	4.8	2.2
% Natural Gas Heated	[illegible]	[illegible]	[illegible]	59.5	57.7	56.1	55.2	54.7	-0.5	-0.4
% Oil and Other Heated	17.3	17.5	17.3	15.7	14.3	13.2	12.5	12.1	-1.8	[illegible]

PROJECTED ENERGY DEMANDS FOR THE WEST NORTH CENTRAL REGION (Cont'd.) (9)

	YEARS								%CH	%CH
	1978	1979	1980	1985	1990	1995	2000	2003	78 TO 90	90 TO 03
MOTOR GASOLINE(millions of gallons)	10,181.5	10,309.5	10,160.7	10,002.2	9,920.3	10,566.5	11,532.0	12,219.0	-0.2	1.7
ELECTRICITY(billion kwh)										
Demands										
Residential	55.8	58.9	61.5	82.1	104.8	123.1	138.6	147.5	5.4	2.7
Commercial	41.7	42.9	42.5	51.0	59.9	64.5	69.5	73.1	3.1	1.5
Industrial	43.5	45.7	48.2	75.2	106.5	131.1	154.1	158.2	7.7	2.6
Transportation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Interdepartmental	0.3	0.3	0.4	0.5	0.7	0.9	1.0	1.1	7.4	3.5
Total	141.4	147.9	152.8	208.9	272.0	319.6	363.5	390.0	5.6	2.8
Generation	164.7	172.4	177.2	238.1	305.9	357.9	407.1	436.7	5.3	2.8
Gen. to Demand Ratio	1.2	1.2	1.2	1.1	1.1	1.1	1.1	1.1	-0.3	0.0
Generating Capacities (thousand megawatts)										
Coal	24.7	25.3	27.3	33.5	42.5	54.2	52.5	58.0	4.6	1.7
Oil	5.2	5.3	5.5	5.8	5.5	5.4	5.2	5.3	0.9	-0.7
Natural Gas	5.5	5.5	5.4	5.1	4.4	2.6	2.7	1.9	-1.9	-6.2
Nuclear	3.4	3.4	3.4	5.7	6.6	8.6	10.1	11.1	5.7	4.2
Hydro	3.3	3.3	3.2	4.3	4.3	4.2	4.3	4.3	2.2	0.0
Solar	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	NC	9.5
Exotic	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	42.1	43.8	45.4	55.4	64.4	77.5	86.0	91.4	3.5	2.7
UTILITY FUELS(trillion btu)										
Coal	1,190.2	1,270.0	1,257.5	1,360.5	2,569.5	3,170.4	3,630.7	3,898.9	7.0	3.0
Fuel Oil	50.1	95.0	56.0	38.3	48.5	0.0	0.0	0.0	-1.8	-100.0
Natural Gas	143.6	128.1	122.3	109.1	39.7	73.3	60.5	59.2	-3.8	-3.1
Nuclear	224.5	229.1	229.1	298.9	395.2	527.9	613.3	678.5	4.8	4.2
Hydropower	133.1	150.3	150.3	145.4	145.4	145.4	145.4	145.4	0.7	0.0
NATURAL GAS(trillion btu)										
Demands										
Residential	518.4	532.1	546.6	605.3	564.0	693.0	723.4	741.5	2.1	0.9
Commercial	295.1	303.1	310.8	356.5	387.0	420.9	460.9	495.6	2.3	1.9
Industrial	703.3	725.3	639.4	552.2	552.7	543.4	431.3	347.0	-2.0	-3.5
Total	1,516.9	1,561.1	1,496.3	1,514.7	1,504.1	1,657.5	1,615.1	1,584.1	0.5	-0.1
Natural Gas Availability	1,675.5	1,599.1	1,529.6	1,520.9	1,593.3	1,721.0	1,576.3	1,543.0	0.1	-0.2
PRICES										
Marginal Residential Elec. (1)	3.4	3.6	4.1	5.4	6.5	8.8	11.6	14.1	5.5	5.1
Average Commercial Elec. (1)	3.7	4.1	4.7	5.5	8.0	11.7	16.0	19.6	7.0	6.3
Average Industrial Elec. (1)	2.8	3.1	3.6	5.1	6.4	9.1	12.3	15.1	7.0	6.8
Average Residential Gas (2)	21.5	23.9	25.0	45.1	72.8	136.1	222.0	278.9	10.8	10.8
Average Commercial Gas (2)	18.5	20.9	21.9	42.0	70.0	132.0	209.2	274.6	11.7	[illegible]
Average Industrial Gas (2)	14.8	17.1	21.6	52.1	80.7	135.5	215.1	282.4	15.0	10.1
Coal - Electric Utilities (3)	0.9	1.0	1.1	1.6	2.4	3.6	5.1	6.4	9.0	7.7
Oil - Electric Utilities (3)	1.9	2.0	2.7	4.8	7.2	11.5	18.8	24.9	11.8	10.0
Natural Gas - Elec. Util. (3)	1.2	1.3	1.5	3.0	5.3	10.4	16.7	22.1	13.1	11.5
ECONOMIC INDICATORS										
Residential Population (4)	16.9	17.0	17.1	18.0	19.0	19.9	20.7	21.1	1.0	0.8
Disposable Income (5)	108.6	121.4	133.3	219.8	342.4	520.2	771.3	979.8	10.0	8.4
Commercial Employment (6)	4,335.8	4,443.2	4,537.4	5,133.3	5,569.4	5,943.4	6,203.0	6,384.8	2.1	1.0
Housing Stock (7)	5,977.9	6,084.6	6,160.6	6,754.1	7,382.1	7,857.1	8,197.0	8,401.4	1.8	1.0
% Elec. Heated	8.5	9.6	10.4	15.6	20.7	25.0	28.7	31.0	7.6	3.1
% Natural Gas Heated	56.3	56.1	56.0	53.4	50.7	58.4	56.4	55.2	-0.8	-0.7
% Oil (and Other) Heated	23.3	23.2	22.7	19.9	17.4	15.5	14.1	12.2	-2.5	-2.1

Notes: (1) Cents per kilowatt hour.
(2) Cents per therm.
(3) Dollars per million BTU.
(4) Millions of persons.
(5) Billions of current dollars.
(6) Thousands of persons.
(7) Thousands of units.
(8) See Note 3 to Table II-4 for states included in ENC.
(9) See Note 4 to Table II-4 for states included in WNC.

Source: DRI Transportation Service.

EXHIBIT II-12

U.S. ARMY CORPS OF ENGINEERS
ROCK ISLAND DISTRICT

UPPER MISSISSIPPI
WATERBORNE GASOLINE TRAFFIC EQUATION

```
                    ORDINARY LEAST SQUARES
                    ----------------------
ANNUAL(1965 TO 1977)    13 OBSERVATIONS
DEPENDENT VARIABLE:    WTT2911UMDEST

          COEFFICIENT   STD. ERROR    T-STAT    INDEPENDENT VARIABLE

             -279644    5.595E+05    -0.4911    CONSTANT

  1)         14.5772        3.302      4.415    DGNTRN@WI+DGNTRN@MN+DGNTRN@IL+DGNTRN@IA+ DGNTRN@MO

  2)        -35.9282        9.179     -3.915    MIMGNPP@P3T2

  3)         -415852    1.268E+05     -3.281    DMYWTHR

R-BAR SQUARED:  0.7043
DURBIN-WATSON STATISTIC:  1.9275
STANDARD ERROR OF THE REGRESSION:  1.526E+05   NORMALIZED:  0.07265

 DATE     ACTUAL      FITTED     * MARKS ACTUAL VALUES

1965    2,034,651   1,844,836         -----*
1966    1,979,046   2,058,050            *--
1967    1,859,963   2,093,334         *------
1968    2,129,196   2,042,303              --*
1969    2,106,900   2,150,392               *-
1970    2,311,523   2,258,995                   -*
1971    2,355,026   2,415,171                     *-
1972    2,255,177   2,328,642                   *--
1973    1,841,734   1,876,142         *-
1974    1,673,049   1,528,541   -*
1975    2,625,543   2,345,122                      -------*
1976    2,386,686   2,410,994                       *-
1977    1,746,141   1,843,027      *--

F-STATISTIC(3,9):   10.53
                                             PARTIAL                  STANDARD   ELASTICITY
                                           CORRELATION      MEAN      DEVIATION   AT MEAN

1) DGNTRN@WI+DGNTRN@MN+DGNTRN@IL            0.827129      298596     35001.9     2.07229
   +DGNTRN@IA+ DGNTRN@MO
2) MIMGNPP@P3T2                            -0.793727     53123.5     12756.7   -0.908685
3) DMYWTHR                                 -0.737972    0.153846    0.360801  -0.0304590
```

	WTT2911UMDEST	is Upper Mississippi River gasoline barge traffic destinations
where	DGNTRN@__ __	is demand for gasoline in each of the Upper Mississippi River states
	MIMGNPP@P3T2	is pipeline flows of gasoline from Gulf Coast to the Midwest
	DMYWTHR	is a dummy variable for 1973-1974 weather and energy problems

Source: DRI Transportation Service.

U.S. ARMY CORPS OF ENGINEERS
ROCK ISLAND DISTRICT

UPPER MISSISSIPPI
WATERBORNE JET FUEL TRAFFIC EQUATION

ORDINARY LEAST SQUARES

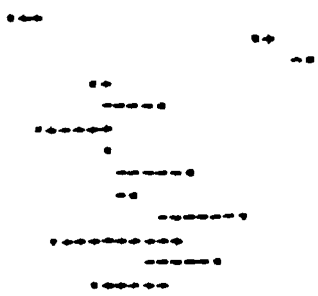
ANNUAL(1965 TO 1977) 13 OBSERVATIONS
DEPENDENT VARIABLE: WTT2912UMDEST

	COEFFICIENT	STD. ERROR	T-STAT	INDEPENDENT VARIABLE
	34758.9	4.592E+04	0.7569	CONSTANT
1)	2.95613	2.101	1.407	DJFTRN@UMDEST
2)	-0.656226	4.635	-0.1416	M1JFKPP@P3T2
3)	125673	3.557E+04	3.533	DMY6667

R-BAR SQUARED: 0.4443
DURBIN-WATSON STATISTIC: 2.9444
STANDARD ERROR OF THE REGRESSION: 3.379E+04 NORMALIZED: 0.3166

DATE	ACTUAL	FITTED
1965	46,956	64,228
1966	186,498	194,166
1967	214,531	206,862
1968	89,065	93,190
1969	131,023	100,256
1970	52,706	98,565
1971	100,951	99,192
1972	144,253	102,466
1973	117,241	110,505
1974	175,445	130,969
1975	67,186	133,085
1976	164,174	128,223
1977	92,738	130,959

* MARKS ACTUAL VALUES



	PARTIAL CORRELATION	MEAN	STANDARD DEVIATION	ELASTICITY AT MEAN
1) DJFTRN@UMDEST	0.424609	23889.3	3068.52	0.576405
2) M1JFKPP@P3T2	-0.0471419	3343.69	3365.57	-0.0179090
3) DMY6667	0.762236	0.153846	0.360801	0.157805

where

WTT2912UMDEST	is Upper Mississippi River jet fuel barge traffic
DJFTRN@UMDEST	is demand for jet fuel in the Upper Mississippi River states
M1JFKPP@P3T2	is movements of jet fuel to Midwest states from Gulf Coast origins
DMY6667	is the Vietnam War fuel use dummy variable

Source: DRI Transportation Service.

EXHIBIT II-14

U.S. ARMY CORPS OF ENGINEERS
ROCK ISLAND DISTRICT

UPPER MISSISSIPPI
WATERBORNE DISTILLATE FUEL OIL EQUATION

ORDINARY LEAST SQUARES

ANNUAL(1965 TO 1977)   13 OBSERVATIONS
DEPENDENT VARIABLE: WTT2914UMDEST

	COEFFICIENT	STD. ERROR	T-STAT	INDEPENDENT VARIABLE
	-549383	4.612E+05	-1.191	CONSTANT
1)	14.5705	4.153	3.508	DDF@UMDEST
2)	-19.7719	6.834	-2.893	M1DFPP@P3T2
3)	-390057	1.384E+05	-2.819	DMY68

R-BAR SQUARED: 0.5962
DURBIN-WATSON STATISTIC: 1.3230
STANDARD ERROR OF THE REGRESSION: 1.308E+05   NORMALIZED: 0.1327

DATE	ACTUAL	FITTED	* MARKS ACTUAL VALUES
1965	750.245	864.326	*---
1966	930.321	984.192	*-
1967	1,059.388	985.034	------*
1968	623.455	623.455	*
1969	1,104.735	1,021.120	--*
1970	1,086.658	986.096	---*
1971	1,029.375	1,120.748	*---
1972	1,077.002	1,245.754	*-----
1973	931.203	916.195	*
1974	772.735	945.487	*-----
1975	1,161.293	1,093.237	--*
1976	1,408.147	1,271.820	----*
1977	976.074	953.568	-*

	PARTIAL CORRELATION	MEAN	STANDARD DEVIATION	ELASTICITY AT MEAN
1) DDF@UMDEST	0.750020	130301	13696.5	1.92853
2) M1DFPP@P3T2	-0.694161	16876.5	8362.35	-0.338599
3) DMY68	-0.684725	0.0769231	0.266469	-0.0304467

where	WTT2914UMDEST	is Upper Mississippi distillate fuel oil barge traffic terminations
	DDF@UMDEST	is demand for distillate fuel oil in the Upper River states
	M1DFPP@P3T2	is movement of distillate fuel oil via pipeline from the Gulf to the Midwest
	DMY68	is a dummy variable for the year 1968

Source: DRI Transportation Service.

U.S. ARMY CORPS OF ENGINEERS
ROCK ISLAND DISTRICT

UPPER MISSISSIPPI
WATERBORNE RESIDUAL FUEL OIL EQUATION

ORDINARY LEAST SQUARES

ANNUAL(1965 TO 1977) 13 OBSERVATIONS
DEPENDENT VARIABLE: WTT2915UMDEST

	COEFFICIENT	STD. ERROR	T-STAT	INDEPENDENT VARIABLE
	-295654	3.767E+04	-7.849	CONSTANT
1)	6.26070E+06	1.238E+05	50.57	MKTSHR2915@UMDEST
2)	7.67013	0.9216	8.323	DRF@UMDEST

R-BAR SQUARED: 0.9959
DURBIN-WATSON STATISTIC: 2.7558
STANDARD ERROR OF THE REGRESSION: 9678 NORMALIZED: 0.03040

DATE	ACTUAL	FITTED
1965	337.029	337.829
1966	375.174	387.992
1967	281.152	277.296
1968	313.151	310.367
1969	198.345	199.557
1970	20.933	35.970
1971	260.301	254.041
1972	262.748	250.873
1973	196.488	202.700
1974	329.701	320.360
1975	549.325	549.343
1976	605.314	615.513
1977	408.610	395.841

• MARKS ACTUAL VALUES

	PARTIAL CORRELATION	MEAN	STANDARD DEVIATION	ELASTICITY AT MEAN
1) MKTSHR2915@UMDEST	0.998050	0.0529480	0.0248036	1.04117
2) DRF@UMDEST	0.934797	36837.1	3332.25	0.387439

where WTT2915UMDEST is Upper Mississippi residual fuel oil barge traffic terminations

MKTSHR2915@UMDEST is the historical market share of barge traffic in total Upper River residual oil use

DRF@UMDEST is total residual fuel oil consumption in the Upper River states

Source: DRI Transportation Service.

EXHIBIT II-16

U.S. ARMY CORPS OF ENGINEERS
ROCK ISLAND DISTRICT

ROCK ISLAND DISTRICT BARGE TRAFFIC
FORECASTING EQUATION FOR CEMENT

ORDINARY LEAST SQUARES

ANNUAL(1969 TO 1977) 9 OBSERVATIONS
DEPENDENT VARIABLE: I3241TOT

	COEFFICIENT	STD. ERROR	T-STAT	INDEPENDENT VARIABLE
	-1.74136E+06	2.555E-05	-6.817	CONSTANT
1)	56.2333	6.198	9.072	EEA@UMISS
2)	164590	2.517E+04	6.540	DMY7172

R-BAR SQUARED: 0.9140
DURBIN-WATSON STATISTIC: 1.3841
STANDARD ERROR OF THE REGRESSION: 2.687E-04 NORMALIZED: 0.04596

	PARTIAL CORRELATION	MEAN	STANDARD DEVIATION	ELASTICITY AT MEAN
1) EEA@UMISS	0.965430	40715.4	1688.00	3.91525
2) DMY7172	0.936471	0.222222	0.415740	0.0625459

where I3241TOT = Total Rock Island District cement traffic via barge

EEA@UMISS = Total employment in the Upper Mississippi River states

DMY7172 = Dummy variable for the years 1971 and 1972

Source: DRI Transportation Service.

EXHIBIT II-17

U.S. ARMY CORPS OF ENGINEERS
ROCK ISLAND DISTRICT

TOTAL ROCK ISLAND DISTRICT BARGE TRAFFIC: ESTIMATED TONNAGE DENSITY BY PORT EQUIVALENT (1) 1969 to 2001

	'312'	'314'	'316'	'318'	'320'	'322'	'324'	'326'	'328'	'330'	'332'	'334'
1969	16,653,380	16,392,710	15,992,938	15,655,528	14,618,065	14,231,533	13,765,678	13,308,923	12,499,386	10,847,122	10,861,158	10,254,170
1970	19,790,036	19,440,406	18,985,255	18,774,608	17,466,059	16,989,199	16,397,424	15,805,401	14,711,814	13,059,456	13,074,270	12,372,145
1971	19,251,970	18,841,613	18,334,322	18,005,269	16,622,270	16,217,151	15,695,826	15,682,837	14,521,927	12,742,654	12,777,534	12,031,680
1972	21,840,461	21,304,798	20,749,217	20,313,254	18,401,128	17,918,644	17,260,257	17,079,845	15,988,742	14,100,355	14,129,863	13,319,781
1973	20,934,045	20,456,930	19,960,186	19,606,665	17,735,713	17,348,338	16,788,437	16,441,151	15,486,949	13,757,543	13,810,989	12,481,654
1974	22,725,743	22,134,404	21,523,128	21,220,044	19,319,171	18,932,141	18,416,218	17,590,277	16,490,151	14,713,635	14,770,855	13,450,293
1975	21,836,990	21,165,949	20,610,150	20,310,361	18,387,501	17,939,241	17,387,725	16,230,900	15,348,658	13,502,768	13,473,505	12,197,720
1976	22,796,931	22,276,875	21,366,465	20,906,452	18,993,516	18,371,269	17,633,959	16,155,586	15,478,317	13,716,051	13,811,737	12,659,555
1977	22,357,914	21,735,052	20,898,268	20,499,694	18,515,272	17,944,944	17,350,812	15,917,868	15,178,232	13,375,668	13,471,387	12,137,382
1978	24,331,590	23,749,701	22,810,623	22,407,325	20,182,623	19,518,286	18,895,527	17,250,228	16,477,426	14,522,184	14,597,648	13,117,157
1979	24,969,373	24,325,658	23,287,084	22,815,720	20,510,082	19,838,347	19,144,356	17,468,510	16,659,024	14,129,524	14,727,728	13,283,359
1980	25,913,489	25,234,714	24,170,872	23,680,120	21,299,494	20,594,076	19,870,466	18,123,451	17,281,898	15,181,428	15,280,344	13,799,403
1981	27,167,244	26,446,200	25,315,730	24,805,092	22,348,133	21,619,329	20,865,001	[illegible]	18,128,017	[illegible]	16,019,204	[illegible]
1982	28,234,236	27,404,012	26,294,175	25,768,978	23,238,038	22,482,165	21,701,723	[illegible]	18,799,675	[illegible]	16,607,453	15,006,190
1983	29,407,741	28,619,754	27,371,699	26,824,133	24,206,055	23,418,710	22,606,788	20,621,784	19,593,652	[illegible]	17,296,046	15,643,618
1984	30,370,809	29,547,209	28,272,602	27,708,678	25,030,455	24,216,256	23,380,274	21,326,122	20,268,561	17,785,926	17,894,315	16,204,069
1985	31,357,345	30,504,174	29,145,700	28,561,550	25,815,193	24,986,092	24,128,605	22,009,520	20,928,476	18,353,801	18,464,261	[illegible]
1986	32,493,069	31,623,496	30,196,599	29,600,291	26,746,565	25,867,715	24,992,099	22,787,965	21,683,781	18,981,126	19,093,920	17,313,658
1987	33,364,716	32,471,650	30,973,766	30,359,679	27,447,505	26,554,846	25,659,901	23,395,587	22,270,176	19,481,268	19,596,690	[illegible]
1988	34,610,618	33,686,242	32,100,425	31,461,588	28,455,868	27,536,762	26,609,977	24,258,253	23,109,730	20,195,692	20,314,007	[illegible]
1989	36,014,988	35,069,095	33,366,732	32,707,751	29,571,226	28,606,284	27,653,542	25,203,527	24,030,820	20,955,457	21,076,348	[illegible]
1990	37,564,387	36,539,001	34,751,283	34,058,580	30,798,079	29,800,995	28,810,037	26,251,981	25,059,385	21,822,806	21,947,407	19,961,626
1991	38,766,156	37,762,614	35,841,866	35,124,538	31,769,357	30,741,720	29,719,746	27,078,019	25,864,624	22,510,924	22,638,263	20,609,000
1992	40,112,401	39,079,136	37,073,877	36,330,407	32,876,767	31,817,474	30,761,571	28,010,321	26,799,229	23,311,996	23,443,054	21,357,598
1993	41,083,275	40,020,454	37,926,007	37,157,314	33,603,461	32,511,192	31,426,834	28,620,098	27,364,682	23,788,287	23,920,032	21,793,016
1994	42,119,080	41,026,011	38,839,124	38,044,146	34,387,129	33,261,296	32,147,178	29,262,179	27,983,628	24,311,160	24,443,929	22,273,427
1995	43,068,216	41,944,412	39,660,088	38,838,388	35,074,824	33,914,462	32,771,618	29,810,468	28,505,928	24,747,824	24,880,730	22,669,113
1996	44,180,783	43,025,459	40,637,954	39,788,012	35,911,831	34,718,588	33,544,544	30,499,203	29,168,417	25,306,245	25,440,272	23,182,398
1997	45,266,442	44,079,191	41,584,555	40,705,557	36,717,601	35,486,497	34,281,236	31,152,095	29,795,320	25,832,323	25,967,136	23,664,007
1998	46,398,003	45,178,239	42,571,710	41,662,523	37,556,872	36,289,052	35,051,452	31,835,780	30,453,377	26,384,367	26,520,120	24,170,165
1999	47,524,539	46,271,709	43,547,707	42,607,353	38,379,721	37,074,071	35,803,817	32,500,451	31,091,140	26,917,022	27,053,440	24,656,614
2000	48,704,552	47,417,955	44,570,304	43,597,512	39,243,111	37,898,609	36,594,545	33,199,788	31,762,543	27,477,518	27,614,727	25,169,089
2001	49,904,918	48,583,937	45,606,670	44,600,211	40,114,378	38,729,833	37,391,204	33,902,624	32,436,728	28,038,399	28,178,336	25,681,104

Note: (1) Due to allocation and rounding errors, historical data may not agree with published Rock Island tonnage at locks information. For identification of port equivalents, see Exhibit II-1.

Source: DRI Transportation Service.

III - CONSTRAINT ANALYSIS

The principal assumption behind the barge traffic forecasts presented in Section II is that the technical capability of the waterway system is adequate to accommodate projected traffic. As part of the constraint analysis, this assumption is relaxed. Specific constraints that might reduce future traffic below forecasted levels are identified and analyzed.

The potential constraints addressed in this study include:

- Lock capacity.
- Navigational constraints.
- Legal constraints on commercial development.
- Terminal capacity.
- Fleeting space.
- Winter navigation.
- Conflicts with recreational use.

Each of these constraints will be discussed under a separate subheading. In general, the discussion of each constraint will include an assessment of current operations and problems, description of methodology, statement of findings, statement of conclusions, and evaluation of possible solutions.

LOCK CAPACITY

The nine-foot channel project for the Upper Mississippi was made possible by the construction of 29 dams and locks. The GREAT II area includes 12 separate dams from Lock 11 at Guttenburg, Iowa at the north end of the district to Lock 22 at Saverton, Missouri at the south end. The following subsection discusses current lock operations and problems.

(a) Lock Operations and Problems

The Corps of Engineers can regulate the river flow at each dam. This capability makes it possible to have safe and efficient navigation under widely varying river flow conditions. A lock chamber is constructed at each dam; the level of water depth in each chamber can be raised or lowered so that traffic can move from one pool to another.

Exhibit III-1 lists the relevant physical characteristics of each lock chamber in the Rock Island District. As can be seen, 11 chambers are 600 feet long by 110 feet wide. The chamber at Lock 19 is 1,200 feet long and 110 feet wide. There are smaller, auxiliary chambers at Locks 14 and 15.

Inspections of Performance Monitoring System (PMS) data collected by the Corps of Engineers and interviews with barge and towing companies indicate that there are at least six different types of lockages at each of the 12 main chamber locks. These types of lockages are called: straight, double, setover, knock-out, other commercial, and recreational. A brief description of each type of lockage is provided in Exhibit III-2. Figure III-1 depicts the type of locking activity that occurred during 1977 at Lock 22. As can be seen, double lockages accounted for only 44% of total lockages, but these lockages accounted for over 70% and 80% of total locking time and total tonnage passing the lock, respectively. Double lockages account for the majority of the tonnage passing Lock 22, because of the much larger average number of barges per locking event (see Table III-1 for a comparison of the average number of barges per lockage type). Double lockages also account for the majority of locking time at Lock 22, because the average process time for double locking events is far greater than for other lockages (see Table III-1 for a comparison of average process time per lockage type).

Table III-1

Comparison of Average Tow Size and Processing Time(1) by Type of Lockage (1977 Data for Lock 22)

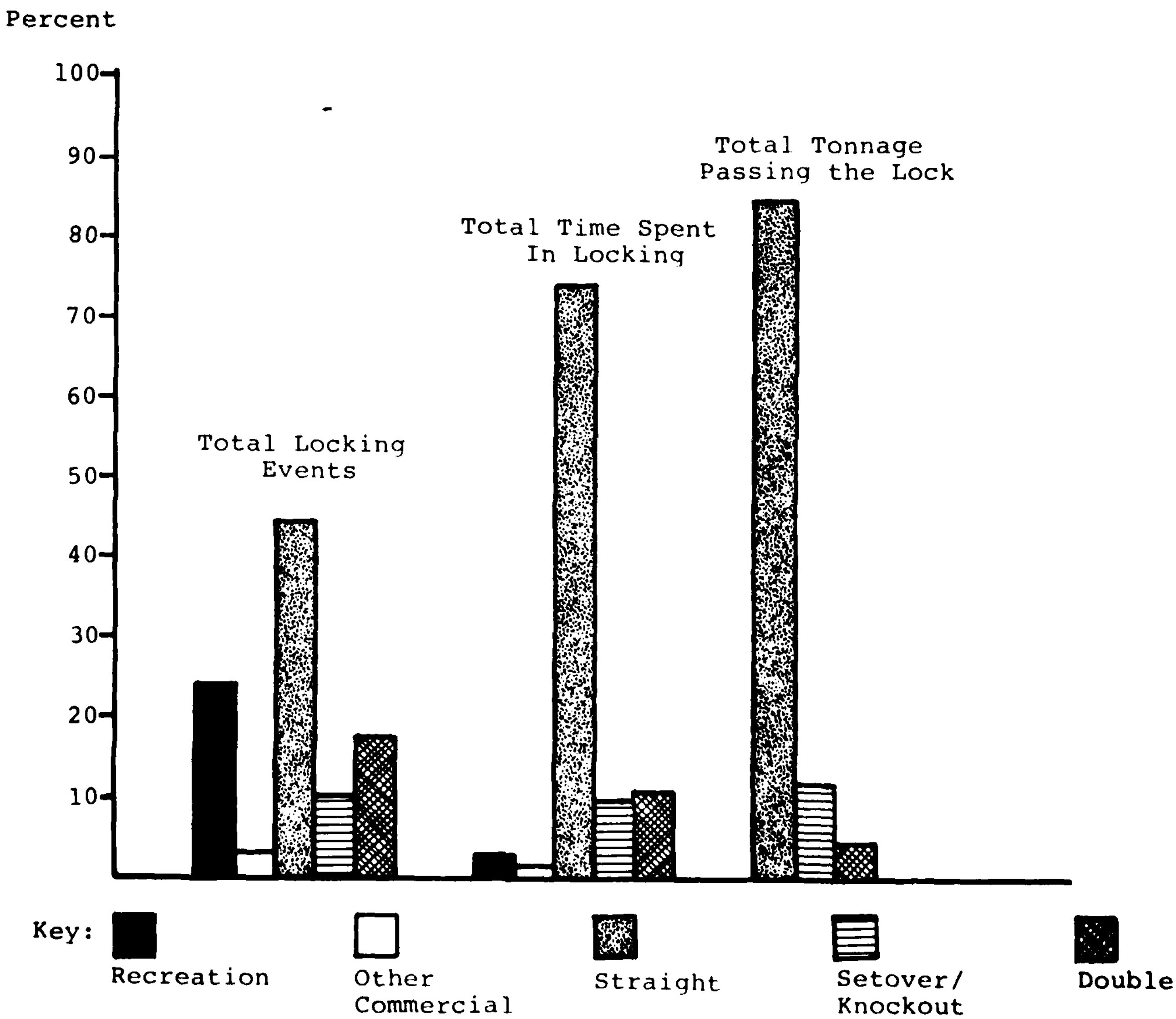
Type of Lockage	Average Tow Size (Barges)	Average Processing Time (Minutes)
Straight	2.9	42
Double	13.0	124
Setover	3.8	73
Knockout	4.3	60
Other Commercial	0.3	33
Recreational	-	17

Note: (1) Processing time includes time for approach, entry, chambering, and exit. For a definition of approach, entry, chambering, and exit, see Note (1) Exhibit III-6.

Source: U.S. Corps of Engineers, 1977 PMS Data.

Figure III-1

Analysis of Locking Activity at Lock 22[1]



Note: (1) See Exhibit III-2 for descriptions of lockage types.

Source: U.S. Corps of Engineers, 1977 PMS data.

Interviews with representatives of the barge and towing industry and the Corps of Engineers were conducted to identify navigational problems posed by the locks. These representatives revealed that:

1. The downbound approach to Locks 19 and 22 posed navigational problems.

2. Bridges at Locks 15 and 19 could interfere with normal locking operations.

(See Exhibit III-3 for a complete listing of the companies contacted by A. T. Kearney for the constraint analysis.) The downbound approach to Lock 19 is difficult to navigate because the channel width is restricted by breakwalls extending from both sides of the riverbank. The Corps of Engineers informed A. T. Kearney that at least one of these breakwalls would be removed and no further discussion of this will be made. The downbound approach to Lock 22 is also difficult to navigate because the channel is narrow and the river current can be swift. In fact, for a distance of 1-1/2 miles, the channel just north of Lock 22 is restricted to one-way traffic for tows. As will be discussed later, the restrictive downbound approach to Lock 22 does reduce lock capacity. Possible solutions to this problem are also discussed. Finally, the locking operations at Locks 15 and 19 are affected if the bridges at these points are closed to barge traffic. To the extent that locking activity appears to be inadequate at these points to handle future traffic, possible solutions to these problems will be discussed.

Representatives from the barge and towing industry and the Corps also indicated that:

1. Waiting time at Lock 22 is of increased concern in recent years.

2. There are no special queuing procedures in effect at any of the locks throughout the Rock Island District.

Analysis of 1977 PMS data confirmed that total delay hours at Lock 22 were larger than at any other lock in the Rock Island District. One barge company source indicated that delay time at Lock 22 was becoming a special problem as a result of the locking procedures in effect at Locks 26. As a result of the extreme congestion at Locks 26, the Corps of Engineers have instituted special locking procedures that call for processing four upbound tows followed by four downbound tows. As these upbound tows move further north, they can arrive "in sequence" at Lock 22. Since the lockmaster at Lock 22 usually processes one upbound tow followed by a downbound tow, the wait for the other upbound tows at Lock 22 can be even longer than the average tow delay. This phenomenon suggests that

it may be necessary for the Corps to adopt a system approach to processing traffic by instituting special locking procedures from Locks 26 all the way up the Mississippi River. The Rock Island District has not instituted special locking procedures, such as those in effect at Locks 26, at any of its locks. The possible benefits from instituting such procedures will be discussed in detail as a means of increasing lock capacity at key locks identified as possible constraints in the future.

(b) Method of Analysis

The method of analyzing the demand in 1980, 1990, and 2000 for lock capacity represented by projected traffic flows was briefly outlined in Section I. A more detailed discussion of A. T. Kearney's approach is discussed below. The approach involved comparing the demand for lock capacity as indicated by the amount of time required to lock projected traffic through each lock with the supply of lock capacity as indicated by the number of hours that each lock is available for processing traffic during the open season. There were at least eight different steps.

1. Compute tonnage passing each lock. The first step involved computing the amount of tonnage passing each lock by commodity and direction. All traffic (i.e., through, within, inbound, and outbound) was analyzed. The specific terminating PE (for an identification of port equivalents see Exhibit II-1) had to be identified for all inbound traffic to determine which of the 12 locks this traffic flow would pass. The specific originating PE had to be identified for all outbound traffic. Finally, the terminating and originating PEs had to be identified for within traffic. (See Exhibit II-5 for summary traffic data. Traffic data classified by concept, commodity, and PE could not be published without disclosing confidential company shipments.)

2. Specify type of tow for each commodity movement. It was necessary to specify the typical barge lading and tow size for each commodity movement in order to convert tonnage flows into an equivalent number of loaded tows. Wherever possible, A. T. Kearney relied on 1977 PMS data to estimate barge lading and tow size. Unfortunately, the PMS data were not disaggregated enough to be of much use for certain types of specialized dry cargo traffic and most liquid cargo traffic. For this traffic, A. T. Kearney relied on information gathered from carriers, shippers, and lockmasters at Rock Island District locks.

Specifying the barge lading and tow size for commodity movements in 1990 and 2000 is made even more difficult because the barge and towing industry has gradually improved its efficiency by both replacing older, smaller barges with newer, larger barges and pushing slightly more barges per tow. A gradual improvement in operating efficiency (especially for dry cargo traffic) for

1990 and 2000 was considered to be reasonable on the basis of field interviews and an analysis of the equipment register in Transportation Lines on the Mississippi River System (1977) published by the Corps of Engineers. Accordingly, slightly higher barge ladings and tow sizes were incorporated in the analysis for 1990 and 2000.

Table III-2 presents the barge lading and tow size assumptions used in the analysis by type of commodity movement for 1980, 1990, and 2000.

Table III-2

Barge Lading and Tow Size Assumptions

Commodity Movement by Type	Barge Lading/Tow Size (Tons/Number of Barges) 1980	1990	2000
Dry Cargo			
Sand, Gravel, and Rock	1,400/2	1,475/2	1,475/2
Cement	1,400/4	1,475/2	1,475/4
Pig Iron (local shipments only)	1,000/2	1,050/2	1,050/2
All Other(1)	1,400/12-13(2)	1,475/13.5-14	1,475/13.5-14
Liquid Cargo			
Chemical, Gasoline, Distillate Fuel Oil, and Asphalt (local shipments only)	3,000/2	3,000/2	3,000/2
All Other	2,750/4	3,000/4	3,000/4

Notes: (1) A barge lading of 1,500 tons was used for all upbound movements, based on 1977 PMS data for average lading per loaded barge moving north. Since the principal direction of movement for dry cargo is downbound, the barge ladings for downbound shipments have been shown.

(2) A range of values for tow size was used, because the 1977 PMS data indicate that average tow sizes for double lockages at the south end of the district are higher than at the north end.

Sources: Field interviews.
U.S. Corps of Engineers, 1977 PMS data.

3. Analyze factors that affect the willingness of carriers to seek backhauls. As a matter of general practice, some barge and towing companies will supplement their principal business by taking on additional business as a backhaul. For example, a company that moves grain in covered hopper barges from Upper Mississippi origins to the Gulf may supplement this business by moving salt in these barges from Louisiana origins to Upper Mississippi destinations. The extent to which companies seek backhauls influences the total number of barges (empty and loaded) required to move any given amount of tonnage.

The factors that affect the willingness of carriers to seek backhauls were analyzed by conducting field interviews (see Exhibit III-3 for companies contacted by A. T. Kearney) and reviewing other field interviews previously conducted by A. T. Kearney for the National Waterways Study.

Carriers indicated that there were at least three factors that affect their willingness to seek backhauls. One of the first factors mentioned was the types of equipment operated by a carrier. Barge companies that operated specialized, liquid cargo equipment typically do not seek backhauls. Furthermore, some carriers shipping coal in open-top barges to Upper Mississippi destinations may seek backhauls, but find that there is little profitable dry cargo that does not need to be covered during shipment. A second factor is the potential income (revenue less ancillary costs) that a carrier might expect to obtain from a backhaul. Typically, backhauls involving short movements do not offer enough revenue to compensate a carrier for the costs associated with preparing his equipment for handling other commodities. A third factor is the contractual obligations that a carrier must meet during any one season. Longer than expected delays at the destination port or Locks and Dam 26 may put carriers behind schedule in meeting contractual obligations. As a result, these carriers may not be able to accept backhauls. For example, one carrier that ships grain from the Upper Mississippi estimated that accepting a northbound backhaul adds at least another 10 days to his total transit time. Finally, some companies operate a small fleet of barges for the purpose of improving customer service. Typically, these barges operate in dedicated (i.e., loaded in one direction and emptied in the other) service.

In view of these findings, it was determined that the number of loaded tows had to be adjusted for empty returns on the basis of the type of commodity movement.

4. Adjust loaded tows for empty returns. For each of the commodity movements distinguished in Table III-2, it was necessary to adjust loaded tows for empty returns. Shipments of sand, gravel, and rock were assumed to be dedicated shipments. Cement shipments and local shipments of pig iron were also assumed to be dedicated shipments. Shipments of liquid cargo

traffic were assumed to be dedicated shipments as well.

However, all other dry cargo shipments, which include such shipments as grains, dry fertilizer, salt, and coal, were adjusted for empties on the basis of an examination of 1977 PMS data and Waterborne Commerce Statistics. Since the predominant movement of dry cargo traffic has been and is projected to be downbound under the baseline forecast, the total number of barges (and hence tows and lockages) required to ship this traffic can be estimated by determining the number of empty barges moving downbound as a percentage of loaded barges moving downbound. Although these statistics are not available for each of these dry cargo movements, these statistics are available for the Rock Island District by type of lockage.

Exhibit III-4 presents historical data on the number of empty and loaded barges moving downbound in double lockages through each of the locks in the Rock Island District during 1977. (Double lockages have been used as a proxy for all other dry cargo traffic as defined by A. T. Kearney in Table III-2, because double lockages are made up primarily of dry cargo tows.) As can be seen, the number of empties moving downbound through the district locks in double lockages varied little from lock to lock. However, the number of loaded barges moving through these locks as doubles increased dramatically from the north end of the district at Lock 11 to the south end of the district at Lock 22. Of course, the number of empties as a percent of loaded barges declined steadily from the north end to the south end of the district. Data for other years were not available to confirm this pattern because the Corps has been collecting these data and making such reports in recent years only. However, an examination of 1977 Waterborne Commerce Statistics and field interviews indicated that a possible explanation for this pattern is that some of the large shipments of coal going to destinations at the north end of the district are moving north under load and returning empty. These barges moving downbound would appear as empties at each of the locks. At the same time, grain originations are concentrated in the center and south end of the district. These barges moving downbound would appear as additional loads at Lock 14 and south.

The number of empty barges as a percentage of loads moving downbound in double lockages used by A. T. Kearney in its analysis is presented in Table III-3 for each separate lock and year. As can be seen, the estimates for 1980 are identical to the historical pattern of 1977. In 1990 and 2000, however, Kearney chose a smaller percentage. Field interviews indicated that some carriers who shipped coal in open-top barges would be replacing them with covered barges, because the covered barges offer greater flexibility to the carrier in deciding whether to seek backhauls. As a result, it was determined that the percentage of empty barges should be adjusted downward for 1990 and 2000.

The number of empties moving downbound could theoretically fall to zero, but that was not considered to be a realistic possibility. Instead, the midpoint between 1977 historical performance and the theoretical limit of 0% was used in each case.

Table III-3

Assumptions Regarding Empty Returns for Downbound Shipments of All Other Dry Cargo

Lock Number	Empties as a Percentage of Loads Moving Downbound in Double Lockages 1977	1980	1990	2000
11	22%	22%	11%	11%
12-13	21	21	10.5	10.5
14-15	20	20	10	10
16-17	18	18	9	9
18	17	17	8.5	8.5
19-21	13	13	6.5	6.5
22	12	12	6	6

5. Specify type of lockage for each tow. For each of the commodity movements distinguished in Table III-2, it was also necessary to specify the type of lockage required to process each tow. Sand, gravel, and rock shipments were treated as straight lockages. Cement shipments and local shipments of pig iron were also treated as straight shipments. All other dry cargo shipments were considered to require double lockages. Local shipments of liquid chemicals, gasoline, distillate fuel oil, and asphalt were treated as straight lockages, while all other liquid shipments were treated as setover lockages if loaded and knockout or straight lockages if empty.

6. Forecast the number of recreational lockages. A. T. Kearney used forecasts of recreational lockages made by the Midwest Research Institute in a study for the U.S. Corps of Engineers called, Methodology and Forecasts of Recreation Use and Small Craft Lockages on the Upper Mississippi River. The final report was published in July, 1978. Projections of pleasure boat lockages for five-year periods from 1980 to 2000 were made by using regression analysis. One equation related pleasure boat lockages to five variables including a long-distance flow factor, the number of commercial marina slips above and below each pool, the number of commercial lockages, the quality of the resources

in the pools, and the average distance between the locks.

Exhibit III-5 presents historical recreational lockages for 1977 and projected lockages for 1980, 1990, and 2000. As can be seen, recreational lockages at Locks 11, 13, 14, and 15 (the last two locks are in the Quad Cities area) are expected to increase by some 50% in the next 20 years. Recreational lockages at Locks 20, 21, and 22 are expected to decrease due in part to the increased congestion at these locks caused by increased commercial traffic.

7. Determine the time required to lock all traffic. Using 1977 PMS data, it was possible to estimate the average number of minutes required to process each type of lockage at each of the locks in the Rock Island District. The historical performance of 1977 was used as the projected performances for 1980, 1990, and 2000. Exhibit III-6 presents the 1977 actual process times for each lockage type and lock.

8. Determine total time available to lock traffic. The final step in the analysis involved estimating the length of season (and, thus, total time available) for locking all traffic. Monthly PMS data on commodity shipments for 1976 and 1977 were reviewed. The length of season for inbound traffic that terminated south of Lock 14 was assumed to be 43 weeks. The length of season for outbound traffic that originated south of Lock 14 was also assumed to be 43 weeks. The length of season for all other traffic was assumed to be 39 weeks. These estimates of total time available were then reduced by the number of hours lost at each lock during 1977 due to turnbacks (a turnback occurs when the lockmaster must raise or lower the water level in the chamber in order to serve the next tow waiting in line to lock through the chamber) and stalls (any downtime at the locks attributable to extreme fog, hardware malfunction, or accidents is considered to be a stall). Exhibit III-7 lists estimates of hours lost to turnbacks and stalls during the 1977 for each of the district locks.

It should be noted that A. T. Kearney assumed that, for purposes of the lock analysis, all traffic would be evenly spread throughout the length of the season.

(c) Findings

As was noted earlier, A. T. Kearney chose to analyze lock capacity as a potential constraint by comparing the amount of time required to process projected traffic through the locks with the amount of time available at each of the district locks to process traffic during the open season. Exhibits III-8 and III-9 present A. T. Kearney projections of lockages for the baseline commodity forecast in 1980, 1990, and 2000. Exhibit III-8 compares actual

commercial lockages for the Rock Island District in 1977 with projected lockages for 1980. As can be seen in Exhibit III-8, the projected activity at each lock corresponds reasonably well with the actual lock performance in 1977. However, projected straight lockages at Locks 14, 15, and 16 fell short of actual lockages in 1977 and were adjusted as noted. A possible explanation for this shortfall is that there is increased locking activity for barge fleeting purposes in the Clinton and Quad Cities area. Exhibit III-9 presents projected lockages for 1980, 1990, and 2000. Two principal assumptions underlying this analysis must be noted. First, the baseline commodity forecast upon which these lockages are based assumes that there will be adequate lock capacity south of the Rock Island District to handle projected traffic. If lock capacity at Locks 26 is not increased by the construction of a new lock chamber(s) by 1990, then the projected increases in locking activity outlined in Exhibit III-9 are not valid. Second, the process of converting tonnage to tows is based on the assumption that the barge and towing industry will be able to achieve improvements by 1990 in barge lading, tow size, and equipment utilization over the historical levels achieved in 1977.

Table III-5 presents A. T. Kearney's findings with regard to lock utilization for the baseline forecasts in 1980, 1990, and 2000. The principal assumption underlying this analysis is that the lock process times in 1980, 1990, and 2000 will not differ from the 1977 historical times, even though traffic levels are expected to be higher. (This assumption will be relaxed in subsequent analysis as alternative solutions to the problem of increased lock congestions and delays is examined. Of course, the assumptions discussed in regard to Exhibit III-9 are also applicable here.) As can be seen, average lock utilization at Lock 22 will be approximately 90% by 1990 and, by the year 2000, there will not be adequate capacity at 22 to handle projected traffic. Lock utilization at Locks 20 and 21 will be approximately 90% and 99% respectively, by the year 2000.

Table III-4

Average Lock Utilization for 1980, 1990, and 2000(1)

Lock	1976(2)	1980	1990	2000
11	43%	43%	49%	64%
12	39	39	45	59
13	38	42	47	61
14	41	47	55	72
15	47	51	59	79
16	46	55	64	84
17	44	50	58	78
18	47	52	60	80
19	42	50	59	77
20	48	57	67	90
21	53	61	74	99
22	66	75	90	- (3)

Notes:
(1) Hours spent processing traffic divided by total available hours for locking during open season.
(2) 1976 lock utilization is shown, because the Corps has computed this measure for 1976 only.
(3) Capacity of lock is not adequate to handle projected traffic.

Sources: Exhibits III-5, III-6, III-7, and III-9.
1976 and 1977 PMS data.
DRI Transportation Service.

Before discussing some of the consequences of this increased locking activity, it is appropriate to examine whether the alternative commodity forecasts of energy products including coal, distillate fuel oil, residual fuel oil, asphalt, and crude oil would change the lock utilization findings presented in Table III-4.

DRI developed four alternative scenarios for coal traffic and these alternatives have been outlined in Section II. When compared to the baseline forecast, two of these forecasts (eastern coal growth and increased market share for barge transportation) result in increased upbound shipments of coal moving from mines in Illinois or Kentucky to utility plants located in the north end of the district and the St. Paul District. Exhibit III-10 compares the number of loaded, upbound tows required to move the coal tonnage under each of the three forecasts for 1990 and 2000. As can be seen, the eastern coal growth forecast results in sharply higher traffic by 1990 and 2000. To the extent that coal shippers and carriers pick up grain in the district after they deliver coal at the north end of the district, the eastern coal growth scenario may not lead to an increase in congestion at Locks 20, 21, and 22. However, increased congestion above and beyond that indicated by the baseline forecast will occur if coal carriers ship this coal in dedicated service. The increased barge share scenario also might increase congestion at southern locks, but the amount of increase in coal shipments is much lower than for the eastern coal growth scenario.

In contrast to the two coal forecasts discussed above, the new coal terminal forecast results in an increase in downbound and upbound coal flows. The downbound coal flows amount to 750,000 tons (or approximately 36 tows per year) by 1990 and 1,000,000 tons (or approximately 48 tows per year) by 2000. Although the downbound increases are not large, they will increase lock congestion as the dominant direction of dry cargo traffic is downbound.

The final coal alternative scenario, increased western coal use, results in such small changes in tonnage that the findings regarding lock congestion will not differ materially for this scenario than for the baseline forecast. Thus, the four alternative coal forecasts will not be expected to change the findings of lock congestion presented in Table III-4.

The alternative forecasts for the various petroleum products result in lower upbound flows for different reasons. Distillate fuel oil traffic might be as much as 350,000 tons lower in 1990 and 400,000 tons lower in 2000 than under the baseline forecast, due to increased pipeline congestion. The complete elimination of residual fuel oil due to the conversion to alternative fuels at utility and industrial power plants results in a reduction of 185,000 tons in 1990 and 145,000 tons in 2000. Due to a reduced highway rehabilitation program, asphalt tonnage might not increase beyond the levels reached in 1990. As a result, this lower forecast reduces upbound flows by 60,000 tons and downbound flows by

25,000 tons in 2000. Finally, increased pipeline competition might reduce crude oil upbound flows by 300,000 tons in 1990 and 2000. Assuming each of these separate forecasts are valid, upbound tonnage flows can be expected to be approximately 835,000 tons (or approximately 70 tows per year) by 1990 and 905,000 tons (or 75 tows per year) by 2000 lower than under the baseline forecast. Since the lock analysis adopted by A. T. Kearney is based on the assumption that liquid cargo traffic is moved in dedicated service, the reduction in upbound flows also results in an equivalent reduction in the number of downbound empty tows. These reduced flows result in an approximate reduction in demand for lock capacity of 3% in 1990 and 2000. Thus, if the alternative petroleum product scenarios are valid, then lock utilization and consequent congestion will be lower than the levels indicated by the baseline forecast.

(d) Conclusions from the Analysis

The findings regarding lock utilization shown in Table III-4 indicate that average lock utilization will increase at all locks and demand for lock capacity will reach or exceed capacity at Locks 21 or 22 by the year 2000. The consequences of this increased lock congestion have immediate and long-term financial impacts on carriers, shippers, producers, and consumers. The most immediate impact is an increase in the delay of all traffic seeking to move through individual locks.

In order to determine the possible impact of increased locking activity on lock delays, A. T. Kearney simulated locking activity at each of the main chamber locks in the district for 1980, 1990, and 2000. This simulation is based on a distribution of traffic arrivals at each lock that corresponds to a Poisson distribution, a statistical distribution of discrete events. Table III-5 presents the results of this analysis. It should be noted that the average delay in hours corresponds to the delay experienced only by those commercial tows or recreational vessels that actually were delayed. As can be seen, the percentage of all traffic delayed increases from 1980 to 1990 and from 1990 to 2000 for all traffic at each lock. However, the increase in average delay per delayed event is most dramatic for Locks 20, 21, and 22, in which demand for locking capacity approaches 90% of technical capability by 1990 or 2000.

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BARGE TRAFFIC FORECAST AND CONSTRAINT ANALYSIS FOR GREAT II.(U)

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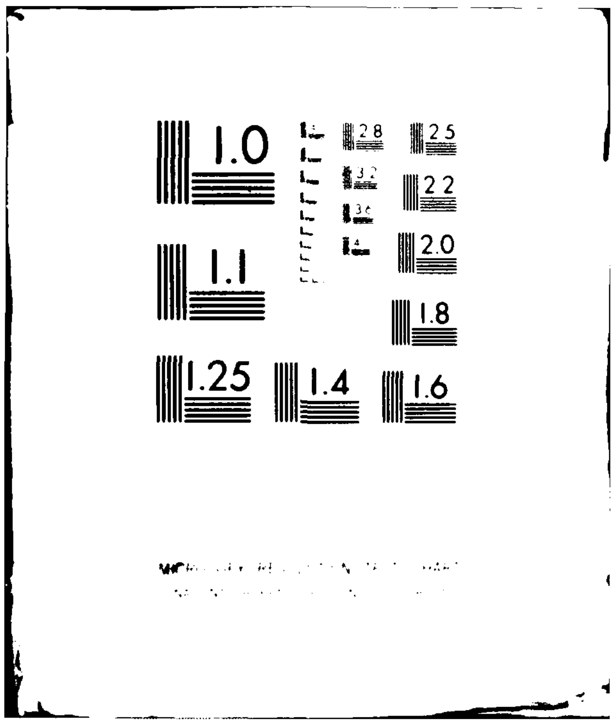
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Table III-5

Percentage of Total Traffic Delayed and Average Delay per Delayed Event

Lock	1980 Traffic Delayed (Percent)	1980 Average Delay (Hours)	1990 Traffic Delayed (Percent)	1990 Average Delay (Hours)	2000 Traffic Delayed (Percent)	2000 Average Delay (Hours)
11	41%	1.1	48%	1.2	64%	1.8
12	42	1.0	45	1.2	59	1.5
13	42	1.0	46	1.1	60	1.5
14	45	1.3	55	1.5	70	2.4
15	46	1.8	57	2.0	76	3.4
16	54	1.6	64	2.0	84	4.3
17	49	1.5	56	1.6	74	2.9
18	49	1.5	59	1.9	77	3.3
19	49	1.1	59	1.3	76	2.3
20	56	1.8	66	2.1	86	5.5
21	59	1.9	71	2.6	91	7.6
22	74	3.2	85	6.5	100	N/A(1)

Note: (1) Not appropriate because lock demand exceeds technical capability.

Sources: Exhibits III-5, III-6, III-7, and III-9.
A. T. Kearney analysis.

This expected increase in delay at district locks will have a dramatic impact on carriers. The expected increase in transit time for all traffic moving from one end of the district to the other and back will be approximately 13 hours by 1990 over 1980 levels (or an increase in total transit time of 10% over the typical transit time of one Upper Mississippi carrier in 1979) and 42 hours by 2000 over 1980 levels (or an increase in total transit time of 32% over the transit time of an Upper Mississippi carrier in 1979). The increase in transit time for 2000 as noted above assumes that some additional capacity will be made available at Lock 22 by 2000 such that delays will not be greater than 1980 levels. If no change in capacity is made and traffic projections equal or exceed the baseline forecast, then delays will increase an indeterminant amount. As can be seen by Table III-6, these delays result in an increase in annual carrier and shipper costs of approximately $5,000,000 by 1990 and $19,000,000 by 2000. These costs account only for a loss in equipment utilization; another important component of cost that would vary by type of cargo in each tow is increased inventory costs.

Table III-6

Increased Cost of Delays for Commercial Tows over 1980 Levels

Year	Total Increase in Delayed Hours	Approximate Cost per Hour per Tow(1)	Total Costs
1990	26,500	$190	$ 5,000,000
2000	97,500	190	19,000,000

Note: (1) In 1979 dollars.

Sources: Table III-5, Exhibit III-9.
A. T. Kearney field interviews.

In addition to the immediate impacts of increased lock delays, there are also some long-term impacts that are perhaps best understood by examining the process of moving grain to export markets.

As part of its work for the National Waterways Study, A. T. Kearney interviewed a number of grain companies. For a number of years, these companies have relied on barge transportation for the export of corn and soybeans and have made substantial capital investments in barge-loading stations located in the interior and export facilities located at the Gulf. With the increasing delays encountered by these shippers at Locks and Dam 26, grain companies have been forced to examine other means of moving grain to export markets. These alternatives were not attractive in the past, but the increased costs associated with marine transportation and the uncertainty over whether there will be adequate lock capacity to handle projected growth in grain shipments have forced these companies to examine other alternatives. These alternatives include:

1. Rail shipments from midwestern states such as Illinois or Iowa, to Gulf and North Atlantic ports.

2. Rail shipments from western cornbelt states, such as Nebraska, to West Coast ports.

3. Rail shipments from midwestern states such as Iowa or Illinois, to terminals on the Great Lakes.

To handle projected traffic increases, reliance on any or all of these alternatives will require substantial new investment

in transportation equipment and terminals. The resulting changes in distribution flows are not likely to be reversed quickly even with the construction of additional lock capacity sometime after the need for such capacity is discovered. Ultimately, the farmer who is producing corn and soybeans in states such as Iowa, Illinois, and Minnesota, will pay for the other means of transporting grain to export market.

(c) Evaluation of Possible Solutions

The evaluation of possible solutions to increasing lock capacity focused on Locks 20, 21, and 22 since these locks had the sharpest increases by 1990 and 2000 in lock utilization (see Table III-4) and lock congestion (see Table III-5). As was noted earlier in the discussion of current lock operations and problems, the downbound approach to Lock 22 poses some unusual problems. In addition, the Rock Island District Corps has not, up until now, instituted alternative locking procedures at any of its locks. The possible benefits of improving the downbound approach to Lock 22 and instituting alternative locking procedures at Locks 20, 21, and 22 will be discussed in detail below.

At the present time, the channel just north of Lock 22 is restricted to one-way traffic. It is narrow and the current can be so swift that it is very difficult for downbound tows to approach the lock chamber without the assistance of another towboat. Because the channel is restricted to one-way traffic, downbound tows must wait at a point 1-1/2 miles north of Lock 22 (called the approach point) and not proceed to the lock until the lock chamber is available and all northbound traffic has passed the approach point. This unusually long distance between the downbound approach point and the lock has meant that downbound tows typically have longer approach times to Lock 22 and upbound tows typically have longer exit times from Lock 22 than do other tows approaching and exiting from other locks in the Rock Island District. Exhibit III-11 is a comparison of the average approach times for downbound tows and average exit times for upbound tows between 10 of the district locks and Lock 22 for the 1976 season.

As can be seen, the differences in average approach times at the 10 locks and Lock 22 varied anywhere from 5 to 11 minutes depending upon the type of downbound tow being processed. The differences in average exit times at the 10 locks and Lock 22 varied anywhere from one to eight minutes depending upon the type of upbound tow being processed. If an improvement could be made to the downbound approach (and hence upbound exit) at Lock 22, these estimates of differences in approach and exit times might

represent reasonable estimates of the potential savings in total locking time and the potential increase in lock capacity that might be realized.

Discussions with the Corps and barge and towing industry representatives indicated that a possible solution to the problem of the downbound approach to Lock 22 is the construction of a mooring cell just north of Lock 22. The construction of a mooring cell would allow southbound tows to approach within several hundred feet of the lock chamber without being in the way of any northbound tow that must exit from the lock chamber after the process of filling the chamber has been completed. The impact of such an improvement on lock congestion at Lock 22 will be evaluated along with one other operating improvement that might be made at Locks 20, 21, and 22.

Another means of increasing lock capacity involves instituting alternative locking procedures. The St. Louis District of the Corps along with the barge and towing industry has instituted alternative locking procedures at Locks 26. At Locks 26, tows are served in sequence of four upbound followed by four downbound. The procedures are designed to minimize the amount of time that the lock chamber must be committed for the makeup of doubles and the breakup and makeup of setovers and knockouts. Tows requiring a double lockage must be made up far enough from the chamber to prevent any blockage of the lock gates. Tows requiring a setover or knockout lockage must also be broken up and made up far enough from the chamber to prevent any blockage of the gates. In order to reduce makeup and breakup times, the St. Louis Corps had to extend the upper and lower guidewalls running from the lock chamber. By extending these guidewalls, the commercial tows that required a makeup and breakup could accomplish these operations alongside the guidewall without fear of losing barges or blocking the lock chamber gates. In addition to guidewalls, winches or helper towboats have to be employed to extract the first (unpowered) cut from the chamber.

Exhibit III-12 presents an indication of the amount of time required to perform makeup and breakup operations at Locks 20, 21, and 22 during 1977. As can be seen, the average number of minutes required for the makeup of a double during 1977 varied by lock from an average of 12 to 15 minutes per event. The average number of minutes required for the breakup and makeup of setovers during 1977 varied by lock from an average of 18 to 21 minutes per event. And the average number of minutes required for the breakup and makeup of knockouts also varied by lock; the range of averages was from three to five minutes per event. These estimates of time requirements represent the potential for time savings that might be realized if makeup and breakup

operations could be restricted to locations away fiom the lock chamber gates.

In order to assess the impact of the construction of a mooring cell north of Lock 22 and the establishment of alternative locking procedures at Locks 20, 21, and 22, A. T. Kearney ran another simulation of locking operations for 1990 and 2000 under the assumptions that these improvements would be made. Table III-7 presents the simulation results. As can be seen, the average delay for all delayed traffic was reduced 0.5 hours in 1990 and from 2.7 to 2.9 hours in 2000 at both 20 and 21. The average delay at Lock 22 was reduced over three hours in 1990. These improvements also increased capacity in 2000 at Lock 22 such that lock capacity was more in line with demand; however, lock demand is projected to be so close to technical capability that the simulation results regarding average delay in hours are not meaningful.

Table III-7

Impact of Mooring Cell Construction at Lock 22 and Modified Locking Procedures on Lock Delays

	1990		2000	
	Traffic Delayed (Percent)	Average Delay (Hours)	Traffic Delayed (Percent)	Average Delay (Hours)
Lock 20				
Without Improvements	66%	2.1	86%	5.5
With Improvements	57	1.6	75	2.8
Lock 21				
Without Improvements	71	2.6	91	7.6
With Improvements	64	2.1	87	4.7
Lock 22				
Without Improvements	85	6.5	100	N/A(1)
With Improvements	74	3.1	100	N/A(2)

Note: (1) Not appropriate because lock demand exceeds technical capability.
(2) Not appropriate because lock demand is too close to lock capability for simulation results to be meaningful.

Source: Exhibits III-5, III-6, III-7, III-9, III-11, and III-12.

In view of the potential benefits from constructing a mooring cell at Lock 22 and instituting alternative locking procedures, the Corps should consider making these changes as traffic and lock congestion increase in the future. As in the case of the St. Louis District at Locks 26, the Rock Island District will need to extend guidewalls and provide winches or possibly helper towboats. It should also be noted that these improvements alone still result in very significant delays at Locks 20 and 21 in 2000 and that these improvements alone will not be adequate to meet lock demand at Lock 22 within the first several years of the next century. Detailed recommendations with regard to the lock constraint analysis are presented in Section IV.

NAVIGATIONAL CONSTRAINTS

This section contains a discussion of possible constraints to safe and efficient navigation. These constraints include channel dimensions (both width and depth), navigational aids, and bridges. Carriers operating on the Upper Mississippi were asked to identify any problems associated with navigation in the Rock Island District (see Exhibit III-3 for a list of the carriers contacted). A. T. Kearney also reviewed carrier surveys conducted for the National Waterways Study. Once constraints had been identified by carriers, A. T. Kearney met with Corps and Coast Guard officials to discuss possible solutions. The Corps was given the authority to maintain the channel by Congress when it originally authorized the nine-foot channel. The Coast Guard has had the responsibility of placing navigational aids and of monitoring vessel safety. The following subsection discusses the findings from this analysis.

(a) Findings

Navigational problems posed by channel width and depth, navigational aids, and bridges will be discussed separately.

1. Channel width and depth. In general, carriers felt that a minimum depth of 11-1/2 feet to 12 feet and a minimum width of 300 feet are necessary for safe and efficient navigation. Since loaded barges and towboats draw 9 feet of water, an additional 2-1/2 feet to 3 feet of channel are necessary to provide adequate control and maneuverability over the tow. Furthermore, since a 15-barge tow is typically 105 feet to 110 feet wide, a channel width of 300 feet is necessary if two oncoming tows are to pass one another without one tow having to pull over to one side of the channel and wait for the other to pass. At river bends, carriers noted that the channel width should be greater than 300 feet, because the length of the tow (a typical 15-barge tow is over 1,100 feet in length) and the need for the towboat captain

to follow the river's turn make a much wider channel necessary.

Barge and towing companies identified 23 locations where the river channel in the Rock Island District has been on occasion narrow and/or shallow (see Exhibit III-13 for a complete listing of these locations). The Corps of Engineers indicated that, in 10 of these areas, their maintenance activities may be hampered in the future by an inability for the Corps and interested parties, such as the U.S. Fish and Wildlife Service and various state government agencies, to agree on acceptable sites for the proper and efficient disposal of dredging materials. In the past, the Corps would make its own determination of how dredging spoils should be properly disposed. Amendments to the 1976 Clean Water Act passed by Congress in 1978 permit states to have a voice in deciding where dredging spoils will be disposed within their state borders. Table III-8 lists the 10 river locations where maintenance activities may be hampered in the future by a lack of acceptable disposal sites.

Table III-8

Potential Navigational Constraints
Due to a Lack of Acceptable Disposal Sites

Pool(1)	River Mile	Reference Point
11	610	Island 189
11	599	Hurricane Island
12	566	Gordon's Ferry
13	538	Savanna, Illinois Crossing to Sabula
13	531	Dark Slough Foot Light
18	426	Keithsburg
18	425	Huron
18	416	Oquawka Lower
19	398-401	Kemp's Landing
20	350	Curtis

Note: (1) Pool refers to the river channel north of a specific lock and dam.

Source: Field interviews.

The Corps indicated that another three of the locations mentioned by carriers as being navigational constraints are definitely problem areas and improving navigation at these locations would require expensive rock cutting and dredging. These locations are:

(a) Smith Chain (pool 14 and river mile 496).

(b) Campbell's Light to Moline Gap Lighted Buoy (pool 15 and river miles 491 to 488).

(c) Edward's River (pool 18 and river mile 431).

The channel at Smith Chain is primarily rock and it needs to be dug out deeper. The channel from Campbell's Light to Moline Gap Lighted Buoy is solid rock and can be very difficult to navigate. A tow must make three hard turns in a row. The channel needs to be reshaped, deepened, and widened. The channel at Edward's River poses a navigational problem, because the river makes a sharp turn and the channel width is no more than 300 feet. It is expensive for the Corps to dredge here since rocks from upstream locations often accumulate at this point in the channel.

The remaining 10 locations cited by carriers as being narrow and/or shallow are recurring problem areas for the Corps and the Corps routinely checks these locations to determine when dredging is required. At each of these locations, the Corps expects acceptable disposal sites to be available in the future.

2. Navigational aids. Barge and towing companies identified four locations in the Rock Island District where navigational aids have been improperly placed or removed in the past. These locations are:

(a) Maquoketa Light and Red Buoy (pool 11 and river mile 589).

(b) Gordon's Ferry (pool 12 and river mile 566).

(c) Campbell's Light to Moline Gap Lighted Buoy (pool 15 and river miles 491 to 488).

(d) Hershey Chute Red Buoy (pool 16 and river mile 460).

The problem at Maquoketa Light is that the red buoy has been placed over time further and further from the light. Depth soundings conducted by the Corps indicate that the buoy could be set in much closer to the light without any fear of groundings.

Gordon's Ferry poses some unusual problems. As was noted earlier, the Corps has not been able to reach an agreement with interested parties over acceptable dredge disposal sites at this location. At times, the channel width has been limited to as little as 175 feet before some maintenance activities by the

Corps were taken to increase channel width. During those times when the channel is narrow, the Corps noted that as many as six buoys per week are pulled out by passing tows. Until these buoys are properly reset, towboat captains navigating this stretch of the river face a great deal of uncertainty and risk.

Navigation from river mile 488 to 491 is very treacherous. As was noted earlier, the channel is narrow, winding, and solid rock. Towboat captains are especially dependent upon well-placed navigational aids along this stretch of the river. Without such aids, pilots must slow down dramatically and face a much greater risk of a sinking or grounding. Since tows must make sharp turns throughout this channel, navigational aids are often pulled off station.

Hershey Chute was another location mentioned by carriers where navigational aids may have been improperly placed in the past. Carriers noted that the channel width had been reduced substantially over the past several years. The Corps noted that the restrictions on channel width may well have been due to improperly placed navigational aids rather than a lack of maintenance dredging. Historical surveys of the area conducted by the Corps indicated that the river depth was adequate for navigation at some distance on the other side of the buoys. Improperly placed navigational aids at this point in the channel may well force a tow to hold over to one side of the channel until an oncoming tow passes.

3. Bridges. Barge and towing companies were also asked to identify any navigational problems posed by bridges. At the present time, 26 railway and highway bridges span the river in the Rock Island District. The following bridges were cited by carriers as posing navigational problems:

(a) Chicago and North Western Railroad (pool 14 and river mile 518) at Clinton.

(b) Rock Island Railroad and U.S. Government Bridge (pool 15 and river mile 483) at Rock Island.

(c) Burlington Northern Railroad (pool 19 and river mile 403) at Burlington.

(d) Santa Fe Railroad (pool 19 and river mile 384) at Fort Madison.

(e) Norfolk and Western Railroad (pool 22 and river mile 310) at Hannibal.

The Chicago and North Western Railroad bridge at Clinton poses navigational problems for southbound tows for several reasons. First, the horizontal clearance of the bridge is 202 feet. Second, the southbound approach to the bridge is further restricted by the placement of a cell just north of the bridge and on the right-descending side of the channel. The cell was placed there to protect the main bridge structure from being hit by tows.

Unfortunately, the cell was placed some 20 feet into the channel and, as a result, the effective channel width has been reduced. Finally, operators of southbound tows must make a sharp turn to the left as soon as they pass the bridge in order to follow the river channel. Some towboat operators find it easier and safer to pass this bridge by coming to a full stop at the bridge and realigning the tow. Carriers are also concerned about the southbound approach to this bridge, because the approach has been made more difficult in recent years by the placement of the cell and the filling in of the riverbank on the right-descending side of the river.

The Rock Island Railroad and Government Bridge is closed to all river traffic for 2-1/2 to 3 hours each day so that workers can commute back and forth from the Arsenal without delay. Although commercial tow operators do have the right to request that the bridge be opened to allow them to pass, few barge and towing companies exercise this right. As was noted earlier, the bridge also interferes with normal locking operations.

The Burlington Northern Railroad bridge is a swing span bridge with no more than 153 feet of horizontal clearance. The southbound passage is made especially difficult by the fact that tow operators must veer to the left before passing under the bridge and then to the right as soon as they pass the bridge.

The Santa Fe bridge poses a navigational problem, because the bridge has a horizontal clearance of 200 feet and was originally placed at an angle to the channel flow. Furthermore, a southbound tow must be very careful not to hit the center pier of the bridge because the current has a left-hand draft created in part by the breakwall just north of the bridge on the right-descending side of the river. Towboat captains noted that the current runs very strong at this bridge and, if for any reason a bridge operator fails to open the bridge after promising to do so, a southbound tow may not be able to stop before hitting the bridge.

The Norfolk and Western Railroad bridge is a swing span bridge with a horizontal clearance of only 153 feet. As a result of this limited clearance, towboat operators have to take special care not to hit any part of the bridge.

(b) Conclusions from the Analysis

Navigational constraints, whether caused by inadequate channel width, improperly placed navigational aids, or restrictive bridges, increase carrier and shipper transportation costs.

Towboat captains indicated that depths of 11 feet as opposed to 11-1/2 feet to 12 feet force them to cut back on tow speed by as much as 25%. At even lower depths, shippers are forced to light-load their barges so that, instead of drawing 9 feet, these barges draw only 8 feet or 8-1/2 feet. Of course, this reduction in average barge lading increases total operating costs by an equivalent amount. At depths below 11-1/2 feet to 12 feet, there are also increased risks of sinkings or groundings with the additional cost of possible environmental damage due to cargo spills.

Towboat captains indicated that widths of less than 300 feet increase total transit time as more tows wait longer at one-way traffic spots. Just as with a reduced depth, reduced channel width increases the risks of sinkings, groundings, and environmental damage due to spills.

Improperly placed navigational aids can increase the risk of groundings and sinkings and, on occasion, can restrict traffic to one direction even though the channel width is adequate to accommodate two-way traffic.

Restrictive bridges increase transportation costs by increasing tow transit time and increasing the risk of an accident.

In view of the major finding from the barge traffic forecast section, that demand for barge transportation will double in the next 20 years, it is reasonable to expect that:

1. Delays at narrow and shallow spots will increase.

2. Costs of accidents and groundings will increase (as barge loadings and average tow size increase).

3. Conflicts with bridge operators will increase (as rail and highway traffic grow).

Possible solutions to these navigational constraints are discussed in the next subsection.

(c) Possible Solutions

The problem of inadequate channel width or depth is primarily a problem of the placement of dredge spoils. If acceptable, practical disposal sites can be found, the Corps will be in a position to properly maintain the channel at all river mile locations listed in Table III-8. The process of selecting disposal sites must be practical insofar as it seeks to minimize the total cost of moving dredged materials from the main channel.

Navigational aids that are improperly placed or removed pose a variety of problems. More frequent checking of buoy placements, especially at known problem areas, will eliminate many of these problems. In addition, improved feedback from barge and towing companies would keep the Coast Guard better informed of problems as soon as they arise.

Restrictive bridges also pose navigational problems. The approach passage and exit from bridges are made even more difficult by any activity or object that restricts the horizontal clearance under the bridge or that forces the tow to turn sharply before or after the bridge. Bridge operators who had better knowledge of the limited maneuverability of southbound tows might also be more careful to open a bridge quickly after committing to a tow.

LEGAL CONSTRAINTS ON COMMERCIAL DEVELOPMENT

This subsection discusses some of the legal constraints that confront any developer who wishes to improve riverfront property. The results of this analysis are applicable to the subsections on fleeting and terminals. A more detailed discussion of this subject is contained in a separate GREAT II report entitled, Commercial River Use: Problems and Needs.

(a) Findings

A. T. Kearney conducted a literature search and a limited number of interviews to identify key constraints on commercial developers of riverfront property in the Rock Island District. Exhibits III-14 and III-15 list the literature reviewed and the organizations contacted by A. T. Kearney. In addition, A. T. Kearney reviewed its field interviews of shippers and carriers conducted for the National Waterways Study.

In general, commercial developers, such as major manufacturing or distributing companies, indicate that the process of obtaining government approval (principally, approval from environmental and wildlife protection agencies) of riverfront property development can be arbitrary and subject to numerous delays. There are at least two principal objections that commercial developers have with regard to obtaining necessary government approval for a particular project; these are:

1. The lack of precision with which regulations can be interpreted.

2. The inability to translate selected evaluation criteria into measures that can be objectively and quantitatively assessed.

Commercial developers have found that, in some cases, the regulations regarding government approval can be interpreted differently either from one location to another or by the government agency enforcing the regulations and the commercial operator interpreting them. Several companies indicated that regulations affecting commercial development are enforced differently from one region to another. If a company prefers to locate in the GREAT II area and runs into opposition, it may seek a riverfront site at another section of the Mississippi and build a similar facility or terminal there. Companies also indicated that their interpretation of the degree to which they had complied with government regulations often differs from the responsible government agencies' interpretation. As a result, a company may feel that it has completed the data collection and analysis efforts only to find that the reviewing agency postpones the review process until additional data are collected and analysis undertaken.

Commercial developers have also found that, on occasion, they are asked to assess the impact of development on certain types of aquatic life, plant life, or recreational activity that are very hard to assess in any objective or quantitative manner. As a result, they argue that their project may be reviewed unfavorably, because it might have a potentially harmful impact that cannot be disproven in an objective manner.

(b) Conclusions from the Analysis

The consequences from this process of reviewing commercial development are that some developers will face long delays and incur substantially higher development costs if they choose to

locate a plant along certain areas of the Mississippi River. In certain instances, a developer may choose to locate a plant or terminal outside the GREAT II area in order to reduce initial investment costs and construction delays. A decision by a company to locate a plant or terminal outside the GREAT II area results in a loss of investment and jobs.

(c) Possible Solutions

The principal objections of commercial developers of river-front property in the GREAT II area were that the process of review can be arbitrary and subject to numerous delays. If reviewing agencies had a limited period of time in which to state what data had to be collected and what analysis had to be performed in order for a particular company's project to be reviewed, then company officials would be able to make a reasonable estimate of the cost of compliance with these requirements and would be assured that no additional requirements would be placed on them at a later date. Furthermore, if evaluation criteria had to be stated precisely, then projects would not be turned down simply because they might have a harmful impact on criteria that cannot be objectively measured in the first place.

TERMINAL CAPACITY

Barge transportation is appropriate for high-volume shipments of bulk commodities between two waterside locations. Cargo is loaded or discharged from barges at waterside terminals. Barge terminals that offer storage and transfer services to the public are designed for general commodity service; there are approximately 13 public terminals in the Rock Island District (see Exhibit III-16 for a list of these terminals). Private terminals are designed to handle one or more products of a particular company; there are approximately 100 private terminals in the district (see Exhibit III-17 for a complete listing of these terminals).

One possible constraint on the growth of barge traffic is a lack of adequate terminal capacity. A. T. Kearney analyzed this constraint by:

1. Reviewing DRI barge traffic forecasts to determine projected originations or terminations by type of commodity for 1980, 1990, and 2000.

2. Selecting two commodities (grain and coal) for detailed analysis.

3. Conducting interviews with terminal operators in the district to identify current problems and determine how new terminal capacity would be obtained in the future.

4. Reviewing carrier and shipper interviews conducted by A. T. Kearney for the National Waterways Study to identify other terminal problems or constraints.

Although DRI forecasted barge originations and terminations by commodity for each of the 12 port equivalents in the district, it is not possible to publish this level of detail without disclosing shipments of individual companies. Projections of originations and terminations by commodity for the entire district can be published and Table III-9 lists projected originations and terminations for 1980, 1990, and 2000. As can be seen by the table, grain and coal are the principal commodities originated and received in the district during the forecast period. The following subsection outlines the potential problems with securing adequate grain and coal terminal capacity in the future.

Table III-9

District Originations and Terminations by Commodity for 1980, 1990, and 2000
(Thousands of Tons)

	1977	1980	1990	2000
Originations				
Corn	4,059	4,926	7,343	9,951
Soybeans	1,313	1,749	1,845	2,279
Wheat	253	281	394	544
Grain Products and Vegetable Oils	896	1,131	2,368	4,298
Terminations				
Coal(1)	1,851	2,022	3,400	3,945
Petroleum	1,246	1,374	2,058	2,308
Fertilizer	1,291	1,390	1,654	1,897
Construction Materials	458	479	542	594
Salt and Pig Iron	254	257	257	260

Note: (1) Baseline forecasts.

Source: DRI Transportation Service.

(a) Findings

Findings with regard to grain and coal are discussed separately.

1. Grain. Grain is the principal commodity originated in the district and, as can be seen by Table III-9, grain shipments from district terminals are expected to more than double over the forecast period. At the present time, there are approximately 30 terminals that originate grain. Grain is typically purchased by terminal operators for truck or rail delivery during the open navigation season from country elevators. The volume of individual terminals differs markedly for a variety of reasons including:

(a) Local crop production.

(b) On-farm consumption.

(c) Competition from grain processors or other terminal operators.

(d) Merchandising ability of the terminal operator.

(e) Terminal storage and shipping capabilities.

(f) Cost and availability of privately owned or purchased barge freight.

(g) Location of terminal with respect to major east-west highways and railroads.

Grain companies indicated that they had several options for increasing terminal capacity in the future. These options include:

(a) Working additional shifts.

(b) Upgrading existing terminals.

(c) Constructing new facilities.

For several grain companies, working longer hours is the easiest means of increasing shipments in the short term. A very small labor force is required to load barges in off hours if it is not necessary to unload truck or rail-delivered grain. A possible problem for terminals located near residential areas is that a third shift may not be permitted by local law.

Several grain companies emphasized the importance of upgrading existing terminals to handle more volume. They noted that grain exports have increased dramatically since the early 1970s, yet only a few export facilities have been constructed at

the Center Gulf (New Orleans, Baton Rouge) in recent years. As in the case of export facilities, operators of inland terminals can increase their capability by making selected improvements to existing facilities, such as:

(a) Increasing the number of truck dumps.

(b) Installing a rail receiving pit.

(c) Increasing terminal storage capacity.

(d) Increasing the capability of the barge loading equipment.

(e) Adding another barge loading spout.

Aside from increasing fleeting space, grain companies indicated that they were usually able to make such improvements with little government interference.

Grain companies also commented on the possibility that they might increase their volume of barge originations by constructing new terminals. As was noted earlier, there are a number of factors that explain differences in the volume handled by individual terminals. However, the crucial factor in determining where a grain company might construct a new facility in the GREAT II area is access to major east-west highways and railroads.

Access to east-west highways and railroads is important to terminals because much of the grain originated in the district comes from points west of the river. Grain terminals in the district typically originate truck-delivered grain from elevators within 100 to 125 miles west of the Mississippi. Although some grain is originated east of the river (this is especially important at the north end of the district), terminal operators face stiff competition for this grain from other terminals located on the Illinois River. In contrast to truck-delivered grain, terminal operators located on certain railroads can receive grain from locations as far as 200 miles west of the river. The greatly expanded draw provided by good rail service makes a location with such service very attractive to grain companies.

The locations of suitable sites for new grain-handling facilities may well be limited in the future by curtailment of rail service in Iowa. The Milwaukee Road has filed to abandon track at Dubuque, Clinton, Quad Cities, and Muscatine. Service on the Rock Island Railroad at the Quad Cities is being handled at the present time by the Kansas City Terminal Association. The

Chicago and North Western has filed to abandon track at Dubuque. This possible curtailment of rail service is perhaps the most important constraint in securing adequate terminal capacity in the future. Possible solutions to this problem will be discussed in a later subsection.

2. Coal. Coal is the principal commodity received in the district. Coal-fired utilities account for the great majority of coal use in the district. Table III-10 presents coal termination in the district under various forecasts for 1980, 1990, and 2000. Under the baseline forecast, coal terminations are expected to double over the forecast period. The baseline forecast is in line with present utility plans and existing government regulations.

Table III-10

Coal Terminations under Alternative Scenarios(1)
(Thousands of Tons)

Scenario	1977	1980	1990	2000
Baseline Forecast	1,851	2,022	3,400	3,945
Eastern Coal Use	1,851	2,168	4,587	6,667
Increased Market Share	1,851	2,306	3,883	4,356
New Coal Terminations	1,851	2,022	3,694	4,337

Note: (1) Coal terminations for the western coal use scenario are comparable to the baseline forecast.

Source: DRI Transportation Service.

At the present time, there are approximately ten terminals that receive coal by water in the district. Utilities receive coal from eastern, midwestern, and western mines. Eastern coal typically moves by truck or rail to a terminal located on the Ohio River. From there, the coal moves by barge to a utility-owned terminal located at the power plant. Midwestern coal typically moves by rail to a terminal located south of the district on the Mississippi River. Several utilities indicated that they used terminals in the St. Louis area for handling midwestern coal. From St. Louis, the coal moves by barge to the power plant. Western coal use in the district comes primarily from utilities located at the northern end of the district. This western coal comes from mines served principally by the Burlington Northern Railroad. Utilities in the district have found the cheapest way to move this coal from the West to their plants that are served only by water is to move it on the Burlington Northern to a point on the Mississippi River and move it from there by water to their power plants. Terminals used by utilities burning western coal

are located in the Twin Cities or St. Louis. A new coal transloading facility has been built at Keokuk, Iowa and is expected to handle western coal in the future.

Utilities indicated that they plan to rely on existing terminals located outside the district (with the exception of the Keokuk terminal, which is expected to be in operation during 1979) to handle additional coal volume in the future. Utilities that receive western coal indicated that they had a financial incentive to put larger volumes of coal through one or two ports. The financial incentive is a result of the rate structure of the Burlington Northern Railroad. Coal rail transportation costs are generally lower for a utility or a group of utilities if they handle more volume through a particular rate location. Thus, utilities in the district that burn western coal are encouraged to use terminals served by the Burlington Northern (or eventually the Chicago and North Western) at the Twin Cities, St. Louis, or Keokuk. Utilities receiving eastern or midwestern coal also expected to continue using terminals located outside the district.

Any terminal constraints to projected barge traffic growth under each of the coal scenarios will be primarily due to problems of capacity at ports outside the district. As in the case of grain companies, coal companies have been very successful at upgrading existing terminals through capital improvements. However, utilities contacted by A. T. Kearney indicated that there have been many problems associated with securing new terminal capacity in the Twin Cities. (It should be noted that the majority of coal terminating in the district moves northbound from eastern and midwestern mines.) When air quality standards were enacted to encourage the use of western coal, several utilities including some with plants located in the district sought to open a new coal-handling terminal in the Twin Cities. Although the proposed terminal had the support of railroads, utilities, and port officials, the proposal did not receive approval from various environmental and wildlife protection agencies. As a result, these utilities have been forced to use other terminals located in the Twin Cities.

(b) Conclusions from the Analysis

Grain companies indicated that they do have several options for increasing terminal capacity in the district to handle projected traffic growth. Two of these options, working longer hours at existing terminals and upgrading existing terminals, typically do not pose problems for these companies. However, the third option, namely the construction of new terminals at key port locations in the district, may be more difficult for grain

companies to pursue in the future, because the number of attractive locations may be reduced in the future by the curtailment of rail service. If rail service is curtailed, grain shippers located from 125 to 200 miles west of the river will have one less alternative for moving their grain to export markets. These shippers may have to move proportionately more grain by truck to the river or by truck to inland terminals located on railroads with direct service to export facilities on the Great Lakes or Gulf.

Coal-burning utilities located on the river are expected to continue to rely primarily on existing coal terminals located outside the district. The exception to this use is the newly built Keokuk facility. Any constraints on projected coal traffic due to inadequate terminal capacity can be expected to arise at ports outside the district. While coal companies and utilities have been very successful in improving existing facilties, the construction of new facilities at certain locations on the river faces a governmental review process that is subject to numerous delays and high costs. This is especially a problem for utilities that burn western coal in the district. These utilities receive their coal from western railroads and are limited to using a handful of key ports with good, western railroad connections. Without the option of building new, more cost-efficient terminals, these utilities are forced to pass higher transportation costs on to their customers.

(c) Possible Solutions

Projected grain traffic may be constrained in the future by a lack of adequate rail service between country elevators located 125 to 200 miles west of the river and selected ports along the Mississippi. In the past, the state of Iowa, grain shippers, and railroads have worked together to upgrade branchlines for hopper-car service. Similar approaches may be necessary to ensure adequate rail service at key ports in the district. These approaches might also include operation of shortline railroads by grain companies or acquisitions of abandoned track by other rail carriers. In addition, state and federal governments may wish to extend and properly maintain highways that serve inland ports.

Projected coal traffic may be constrained in the future by a lack of new terminals outside the district. The process of reviewing proposals for new coal-handling terminals should be streamlined in line with the possible solutions outlined in the subsection on legal constraints on commercial development.

FLEETING SPACE

Fleeting spaces are used by barge shippers and receivers for the temporary storage of loaded or empty barges. Shippers and receivers typically do not have adequate space at their private terminals or leased public terminals for the temporary storage of their barges. This subsection discusses the potential for barge traffic to be reduced as a result of a shortage of fleeting space.

(a) Current Operations and Problems

There are approximately 32 fleeting spaces throughout the district at the present time (see Exhibit III-18 for a complete listing of these locations). These fleeting spaces were identified by field interviews conducted by A. T. Kearney. Fleeting operators indicated that they have sufficient areas to handle present business. A field trip taken by a U.S. Coast Guard officer through the district revealed that there were some potential operating problems. First, some barges were not secured well at several locations. Second, occasionally, barges were being fleeted in areas that were in close proximity to the main channel, thus creating the possibility of a breakaway. (However, Coast Guard reports indicate that there have been only a few breakaways in pools 14 and 16 in recent years.) Third, the officer noted that there has been some damage to trees being used as tiedowns, but this damage was minimal compared to damage from natural erosion of the shoreline. Aside from these minor problems, fleeting appears to be well managed and is clearly not a potential constraint at the present time.

(b) Method of Analysis

A. T. Kearney analyzed fleeting space as a potential constraint to barge traffic growth by:

1. Reviewing DRI forecasts to identify originations and terminations by river segment (this activity represents the demand for fleeting services).

2. Determining the capacity of existing fleeting areas in the district.

3. Identifying those river segments where a shortfall of fleeting space may develop in the future.

4. Evaluating possible solutions to identified shortfalls.

(c) Findings

Exhibit III-19 presents projected originations and terminations by individual river segment. As can be seen, activity will double in nearly every pool over the forecast period. Table III-11 presents an inventory of fleeting areas in the district. The majority of pools have sufficient fleeting space to handle additional traffic. However, pools 16, 17, and 19 have little additional fleeting capacity. Subsequent analysis will focus on fleeting in these pools.

Table III-11

Inventory of Fleeting Areas in the District(1)

Pool	Number of Sites	Number of Barges Typically on Hand	Number of Barges Capacity
11	1	30-40	80
12	5	37-52	102
14	3	35-45	80
16	2	30-40	40
17	2	30-40	40
18	4	24-40	98
19	5	42-72	83
20	4	23-29	94
21	4	24-26	53
22	2	10	24

Note: (1) No fleeting in Pools 13 and 15.

Sources: Field interviews.
U.S. Coast Guard.

Fleeting operators indicated that a good fleeting site must be located:

1. Near terminals (within five miles).
2. In the same pool as customers.
3. Away from the main channel.
4. In a stretch of river with adequate draft.
5. Away from residential and wildlife areas.

Fleeting spaces that are located some distance from terminals force the operator to spend too much time running back and forth

with barges. Fleeting spaces that are located in the same pool as the customers allow the operator to move barges without waiting in line at a lock. Since there is some noise associated with barge fleeting, the ideal site is located away from residential or wildlife areas.

Fleeting operators indicated that many of the good sites have already been chosen. In pools 16, 17, and 19, fleeting operators expected that a doubling in pool activity over the forecast period will require them to seek as much new space as they have at the present time. As a result, additional fleeting sites that are not as desirable as existing sites may well have to be found in each of these three pools.

Fleeting operators in pool 16 indicated that they still might have several options in meeting new demand. First, one operator is presently using an area with a shallow draft for the fleeting of empty barges and this option might be more important in the future. Second, fleeting spaces further away from present customers may also be used; for example, one operator indicated that he might be forced to fleet barges at river miles 475 to 476, which is three miles further from Rock Island than his present fleeting sites. Third, some sites that are not presently suitable for fleeting might be made attractive by undertaking limited development, such as the construction of deadmen on the shore or mooring cells near the river bank. Improvements of any type at a fleeting site require the operator to seek a Corps permit and, depending upon where the location is, the operator may face opposition from environmental and wildlife agencies.

Fleeting operators in pools 17 and 19 indicated that their best option for securing more space in the future is to use sites that are further away from their present customers. It should be noted that the U.S. Fish and Wildlife Service is particularly concerned about the establishment of new fleeting areas in pool 19, because this pool is a wintering area for two species of ducks, the canvasback and redhead.

(d) Conclusions from the Analysis

Fleeting space appears to be adequate in most district pools with the exceptions of pools 16, 17, and 19. If fleeting spaces are not adequate in these pools, terminal operators may be forced to make their own arrangements as best as they can. For example, one terminal operator indicated that it may become necessary to load a full complement of barges at one time as the towboat is

waiting. In extreme cases, terminal activity may be increased in one pool at the expense of another due to a shortage of reasonable fleeting space in the latter pool. Each of these alternatives would represent a substantial cost increase over existing fleeting practices.

(e) Possible Solutions

Terminal activity in pools 16, 17, and 19 may be constrained in the future due to a lack of adequate fleeting sites. Fleeting operators in all three pools may be forced to use sites that are further from their customers. In at least one of these pools (pool 16), it may be necessary to improve some sites by constructing deadmen or cells and conducting a limited amount of dredging. Since any improvements to fleeting sites are subject to review, the evaluation criteria should be stated with sufficient precision to make it possible for the operator to meet these requirements at a reasonable cost and in a timely fashion.

WINTER NAVIGATION

The barge traffic forecasts and lock analysis have been based on the assumptions that winter weather would continue to cause the Upper Mississippi River in the GREAT II area to freeze over and that the Corps would not take special actions to extend the navigation season. The freezing of the Upper Mississippi is in itself a constraint to the development of barge traffic since, for two to three months, activity is brought to a near standstill and terminal operators are forced to rely on other modes for shipment. Although the constraint imposed by winter weather is of great importance to waterway users, it was determined that this study would not concentrate on actions that might be taken to extend winter navigation. Instead, a recent study entitled Economic Analysis of Year-Round Navigation on the Upper Mississippi River would be reviewed.

This study had several objectives including:

1. To assist the Rock Island District in formulating study alternatives.

2. To determine the economic benefits associated with navigation season extension alternatives.

3. To conduct the benefit/cost analysis that will evaluate the study's alternatives.

4. To examine in general terms the economic impacts of an extended navigation season.

The study was not intended to be an engineering study and all engineering requirements for navigation season extension were evaluated by the Corps. The primary purpose of the study was to identify the benefits associated with the study alternative.

Twelve alternatives for season extension were examined. These alternatives included four different stretches of the river including:

1. Grafton, Illinois in the St. Louis District of the Corps to Lock 21.

2. Grafton, Illinois to Lock 18.

3. Grafton, Illinois to Lock 15.

4. Grafton, Illinois to Cassville, Wisconsin.

For each of these different sections of the river, three different navigation season extension periods were selected for analysis:

1. Four-week extension.

2. Eight-week extension.

3. Full season extension.

The analysis of the potential benefits for each of these twelve alternatives indicates that five alternatives have a benefit/cost ratio greater than 1.0 (see Table III-12). These alternatives include limited extension for four weeks from Grafton to Lock 18, Lock 15, and Cassville; extension for eight weeks from Grafton to Lock 18; and full season extension from Grafton to Lock 18.

Table III-12

Benefit/Cost Ratios by Season Extension Alternatives

River Area	Navigation Period: Four Weeks	Navigation Period: Eight Weeks	Navigation Period: Full Season
Grafton to Lock 21	0.3	0.4	0.4
Grafton to Lock 18	1.4	1.3	1.3
Grafton to Lock 15	2.1	0.9	0.8
Grafton to Cassville	1.8	0.7	0.4

Source: General Research Corp., Economic Analysis of Year-Round Navigation on the Upper Mississippi River.

A benefit/cost ratio greater than 1.0 indicates that implementation of the alternative will result in benefits exceeding costs after discounting both benefits and costs by an appropriate rate.

The study recommends that environmental costs, if they exist, should be identified and incorporated in the analysis and that a phased implementation plan of extending the navigation season be adopted.

CONFLICTS WITH RECREATIONAL USE

A. T. Kearney conducted interviews with fleeting operators and barge companies to identify any possible conflicts with recreational users of the river. Fleeting operators indicated that there were some problems associated with vandalism and navigation at night, but these problems were considered to be minor. Barge and towing companies indicated there was little conflict with recreational users aside from the use of locks. The impact of recreational use on lock capacity was discussed in detail under the lock capacity subsection; however, it should be noted that projections of recreational lockages by the Midwest Research Institute for the Corps indicated that future recreational activity should be concentrated at those district locks where the level of commercial traffic is lower. As a result of

this analysis, conflicts with recreational users are not expected to constrain barge traffic in the future.

U.S. ARMY CORPS OF ENGINEERS
ROCK ISLAND DISTRICT

PHYSICAL CHARACTERISTICS OF THE LOCK CHAMBERS IN ROCK ISLAND DISTRICT

Lock Chamber	River Mile Location	Chamber Length	Chamber Width	Lift	Pool Length
11	583	600	110	11	32
12	556.7	600	110	9	26
13	522.5	600	110	11	34
14-Main	493.3	600	110	11	30
14-Auxiliary		320	80		
15-Main	482.9	600	110	16	10
15-Auxiliary		360	110		
16	457.2	600	110	9	26
17	437.1	600	110	8	20
18	410.5	600	110	10	26
19	364.2	1,200	110	38	47
20	343.2	600	110	11	21
21	324.8	600	110	11	19
22	301.2	600	110	11	24

Source: U.S. Corps of Engineers.

U.S. ARMY CORPS OF ENGINEERS
ROCK ISLAND DISTRICT

DESCRIPTION OF LOCKAGE TYPES

1. Straight lockage. A straight lockage occurs when the barges making up the tow and the towboat pushing the tow are able to fit within the lock chamber without any change in the tow configuration.

2. Double lockage. A double lockage occurs when the tow and towboat require two separate (or single) lockages to be processed. Typically, a dry cargo tow of 15 barges is broken up into a single lockage of the first nine barges followed by another single lockage of the remaining six barges and the towboat. The first cut of the nine unpowered barges is extracted from the lock chamber by winches or a helper towboat.

3. Setover lockage. A setover lockage occurs when the tow and towboat are able to fit within the lock chamber only after the towboat and one or two barges are broken away from the original configuration and set alongside the other barges in the tow. Typically, a liquid cargo tow of three larger barges and one smaller barge is broken in such a way that the towboat, the smaller barge, and one of the large barges is set alongside the other large barges.

4. Knockout lockage. A knockout lockage occurs when the tow and towboat are able to fit within the lock chamber only after the towboat has been broken away from the original configuration and set alongside the tow.

5. Other commercial lockages. There are at least three other commercial lockages. A light tow lockage occurs when a single towboat is processed. A multivessel lockage occurs when two towboats pushing a tow are processed. A barge transfer lockage occurs when a tow is transferred from one towboat on one side of the lock to another towboat on the other side of the lock.

6. Recreational lockages. Recreational lockages occur when one or more recreational vessels are processed.

EXHIBIT III-3

U.S. ARMY CORPS OF ENGINEERS
ROCK ISLAND DISTRICT

COMPANIES CONTACTED BY A. T. KEARNEY
FOR CONSTRAINT ANALYSES

	Company Name	Contact
1.	AGRI Industries	Daniel Brophy
2.	Agri-Trans	Jack Haskel
3.	Alter Co.	Bob Gardner
4.	Archway Fleeting and Harbor Service	Lonnie Jacobs
5.	Canton Towing Service	James Caldwell
6.	Cassville River Terminal (Division of Wisconsin Barge Lines)	Robert Hudson
7.	Eastern Iowa Light & Power	Mr. L. Drum
8.	Hall Towing, Inc.	Donna Hall
9.	Interstate Power Co.	Gordon Lee
10.	Iowa Marine Repair Corp.	Tom Edwards
11.	Lee County Marine, Inc.	Paul Mathiasmeier
12.	Lewis and Lawson Harbor Service, Inc.	Carol Lawson
13.	Mid-America Transportation Co.	Captain Steve Butkovich
14.	Mid-America Transportation Co.	Ed Dlubac
15.	Mid-America Transportation Co.	Captain W. B. Fouts
16.	Mid-America Transportation Co.	Captain Albert Rodgers
17.	Mid-America Transportation Co.	Jerry Tinkey
18.	Muscatine Power & Light	Mr. Fletcher
19.	Newt Marine Service	Gary Newt
20.	Northern States Power	David Peterson
21.	P-D Harbor Service Co.	Cleva Percival
22.	Pillsbury Co.	Del Aden
23.	R & R Marine	Roger Seitz
24.	Twin City Barge & Towing	Richard Lambert
25.	U.S. Coast Guard	Lieutenant Bill Hines
26.	U.S. Corps of Engineers (R.I.)	Dick Baker
27.	U.S. Corps of Engineers (Lock and Dam 17)	Mr. Clark
28.	U.S. Corps of Engineers (Lock and Dam 22)	Gary Clark
29.	U.S. Corps of Engineers (Lock and Dam 11)	Mr. Courrier
30.	U.S. Corps of Engineers (Lock and Dam 14)	Mr. Lair
31.	U.S. Corps of Engineers (R.I.)	Hank Pfeister
32.	U.S. Corps of Engineers (N.C.D.)	Ralph Smith
33.	U.S. Corps of Engineers (St. Paul)	Don Wadleigh
34.	U.S. Corps of Engineers (R.I.)	Donn Wagner
35.	U.S. Corps of Engineers (Lock and Dam 20)	Jim Wright
36.	U.S. Fish and Wildlife Service	Thomas Groutage
37.	Valley Line	Captain Buz Beaver
38.	Williams Marine Enterprise, Inc.	Don Williams
39.	Wisconsin Power & Light	Ken Popp

EXHIBIT III-4

U.S. ARMY CORPS OF ENGINEERS
ROCK ISLAND DISTRICT

THE NUMBER OF BARGES MOVING DOWNBOUND IN DOUBLE LOCKAGES THROUGH THE ROCK ISLAND DISTRICT IN 1977

Lock	Number of Empty Barges	Number of Loaded Barges	Empties as a Percent of Loads
11	944	4,375	22%
12	973	4,696	21
13	957	4,574	21
14	1,050	5,162	20
15	1,075	5,147	21
16	1,039	5,743	18
17	1,078	6,081	18
18	1,056	6,290	17
19(1)	-	-	-
20	1,059	7,888	13
21	1,056	8,399	13
22	1,032	8,547	12

Note: (1) Since the chamber at Lock 19 is 1,200 feet long, there are no double lockages.

Source: U.S. Corps of Engineers, 1977 PMS data.

U.S. ARMY CORPS OF ENGINEERS
ROCK ISLAND DISTRICT

HISTORICAL AND PROJECTED
RECREATIONAL LOCKAGES FOR LOCKS
IN THE ROCK ISLAND DISTRICT

Lock	1977	1980	1990	2000
11	2,748	2,305	3,044	3,595
12	2,429	1,570	2,237	2,746
13	2,237	2,659	3,292	3,791
14(1)	3,439	3,378	4,521	5,413
15(1)	2,931	2,243	3,340	4,185
16	1,393	1,147	1,356	1,522
17	1,340	971	1,008	1,053
18	1,477	871	1,041	1,186
19	745	689	781	848
20	775	506	520	536
21	1,043	737	752	768
22	824	477	432	413

Note: (1) Estimates include lockages at both the main and auxiliary chambers.

Sources: U.S. Corps of Engineers, 1977 PMS data. Methodology and Forecasts of Recreation Use and Small Craft Lockages on the Upper Mississippi River.

U.S. ARMY CORPS OF ENGINEERS
ROCK ISLAND DISTRICT

AVERAGE PROCESS TIME(1)
PER LOCKAGE TYPE AND LOCK DURING 1977
(Minutes)

Lock	Double	Setover(2)	Knockout(3)	Straight	Other Commercial	Recreational
11	105	63	50	32	28	15
12	98	65	46	32	24	13
13	95	59	52	31	22	13
14	104	62	52	23	21	14
15	119	69	52	32	23	18
16	106	65	59	33	29	15
17	101	60	54	32	25	13
18	101	63	53	29	21	14
19	-	-	-	61	35	27
20	103	66	54	29	19	13
21	104	67	53	30	18	14
22	124	76	62	42	33	17

Notes: (1) Process times are the averages of the upbound and downbound traffic in 1977. Process time includes approach, entry, chambering, and exit. Approach time is the difference in time between start of lockage when tow is at approach point and bow over sill. Entry time is the difference in time between bow over sill and end of entry. Chamber time is the difference in time between end of entry and start of exit as the gates are opened. Exit is the time between start of exit and the time that stern of outbound tow passes bow of inbound tow or approach point.
(2) Upbound processing time only.
(3) Downbound processing time only.

Source: U.S. Corps of Engineers, 1977 PMS data.

EXHIBIT III-7

U.S. ARMY CORPS OF ENGINEERS
ROCK ISLAND DISTRICT

HOURS LOST TO TURNBACKS
AND STALLS DURING 1977

Lock	Turnbacks[1]	Stalls[2]
11	121	62
12	73	66
13	96	27
14	105	97
15	112	383
16	119	143
17	96	28
18	144	64
19	257	260
20	110	176
21	116	114
22	169	171

Notes: (1) A turnback occurs when the lock chamber must be filled or emptied in order to serve the next tow waiting in line to lock through the chamber.
(2) Stalls are any events, such as fog, or equipment malfunction, that cause downtime at a lock.

Source: U.S. Corps of Engineers, 1977 PMS Data.

U.S. ARMY CORPS OF ENGINEERS
ROCK ISLAND DISTRICT

A COMPARISON OF ACTUAL LOCKAGES FOR 1977
AND PROJECTED COMMERCIAL LOCKAGES FOR 1980(1)

Lock	Double 1977	Double 1980	Setover and Knockout 1977	Setover and Knockout 1980	Straight 1977	Straight 1980(1)	Other(2) 1977	Other(2) 1980
11	904	950	141	177	454	461	95	95
12	939	1,050	158	193	353	394	88	88
13	928	1,050	158	195	395	395	109	109
14	1,035	1,136	212	214	1,002	989(3)	104	104
15	1,046	1,162	276	293	721	692(4)	297	297
16	1,141	1,334	311	314	984	920(5)	114	114
17	1,202	1,414	308	319	690	612	88	88
18	1,234	1,446	321	319	693	612	138	138
19	-	-	-	-	2,313	2,569	228	228
20	1,467	1,652	315	339	544	641	174	174
21	1,507	1,736	339	391	594	672	228	228
22	1,521	1,766	344	398	619	690	105	105

Notes:
(1) See Exhibit III-5 for actual and projected recreational lockages.
(2) Excludes multivessel and barge transfer lockages.
(3) Includes 500 additional straight lockages.
(4) Includes 100 additional straight lockages.
(5) Includes 300 additional straight lockages.

Sources: U.S. Corps of Engineers, 1977 PMS data.
DRI Transportation Service.
A. T. Kearney, Inc.

EXHIBIT III-9

U.S. ARMY CORPS OF ENGINEERS
ROCK ISLAND DISTRICT

PROJECTED COMMERCIAL LOCKAGES FOR
1980, 1990, AND 2000(1)

Lock	Double			Setover and Knockout			Straight			Other Commercial(2)		
	1980	1990	2000	1980	1990	2000	1980	1990	2000	1980	1990	2000
11	950	1,028	1,412	177	186	213	461	604	755	95	95	95
12	1,050	1,132	1,550	193	203	231	394	510	643	88	88	88
13	1,050	1,132	1,550	195	204	233	395	512	643	109	109	109
14	1,136	1,298	1,802	214	233	266	989	1,099	1,228	104	104	104
15	1,162	1,328	1,844	293	338	382	692	886	1,084	297	297	297
16	1,334	1,536	2,130	314	376	425	920	1,116	1,295	114	114	114
17	1,414	1,624	2,250	319	380	431	612	810	1,017	88	88	88
18	1,446	1,668	2,302	319	380	431	612	810	1,017	138	138	138
19	-	-	-	-	-	-	2,569	3,130	4,126	228	228	228
20	1,652	1,954	2,714	339	407	464	641	843	1,052	174	174	174
21	1,736	2,086	2,938	391	482	554	672	885	1,102	228	228	228
22	1,766	2,124	2,988	398	488	562	690	906	1,122	105	105	105

Notes: (1) See Exhibit III-5 for recreational lockages.
(2) Excludes multivessel and barge transfer lockages.

Sources: U.S. Corps of Engineers, 1977 PMS data.
DRI Transportation Service.
A. T. Kearney, Inc.

EXHIBIT III-10

U.S. ARMY CORPS OF ENGINEERS
ROCK ISLAND DISTRICT

NUMBER OF UPBOUND COAL TOWS
UNDER ALTERNATIVE SCENARIOS FOR
1990 AND 2000

	11	12	13	14	15	16	17	18	19	20	21	22
1990 - Upbound Tows with Loads												
Baseline	309	330	330	374	376	392	392	392	392	392	392	392
Eastern Coal Growth	415	442	442	502	504	527	527	527	527	527	527	527
Increased Market Share	353	376	376	426	428	446	446	446	446	446	446	446
2000 - Upbound Tows with Loads												
Baseline	354	378	378	429	431	449	449	449	449	449	449	449
Eastern Coal Growth	603	644	644	730	734	766	766	766	766	766	766	766
Increased Market Share	395	421	421	478	480	500	500	500	500	500	500	500

Sources: Table III-2.
DRI Transportation Service.

U.S. ARMY CORPS OF ENGINEERS
ROCK ISLAND DISTRICT

AVERAGE APPROACH AND EXIT
TIMES FOR 1976 SEASON(1)
(Minutes)

Lock	Approach Time for Downbound Tows		Exit Time for Upbound Tows	
	Fly/ Exchange(2)	Turnback(3)	Fly/ Exchange(3)	Turnback(3)
11	9	8	6	4
12	11	10	5	4
13	9	7	5	6
14	6	5	4	4
15	9	7	6	6
16	13	6	10	4
17	17	9	8	5
18	11	7	5	5
20	10	6	8	5
21	15	7	6	5
Average for 10 Locks (Excludes Locks 19 and 22) (4)	11	7	6	5
22	22	12	14	6

Notes: (1) For a definition of approach and exit times, see Exhibit III-6.
(2) Fly and exchange refer to the type of locking event. A fly occurs when a tow exits from a lock chamber and no other tow is waiting to be processed. An exchange occurs when a tow moving in one direction is processed just after a tow moving in the opposite direction.
(3) A turnback occurs when one tow is processed just after another tow moving in the same direction.
(4) Approach and exit times for Lock 19 were excluded from the analysis, because they are unusually high due to interference from the breakwall located north of the lock.

Source: U.S. Corps of Engineers, 1976 PMS data.

U.S. ARMY CORPS OF ENGINEERS
ROCK ISLAND DISTRICT

ESTIMATED TIME LOST DURING 1977
FOR MAKEUP OF DOUBLES AND MAKEUP
AND BREAKUP OF SETOVERS AND KNOCKOUTS(1)

Lock	Type of Lockage	Number of Events in 1977	Hours Lost in 1977 to Breakup and Makeup	Average Minutes for Makeup and Breakup per Event	Average Minutes for Makeup Only per Event
20	Double	1,467	531	N/A	15
	Setover(2)	132	49	22	N/A
	Knockout(3)	88	7	5	N/A
21	Double	1,508	456	N/A	13
	Setover(2)	155	46	18	N/A
	Knockout(3)	90	5	3	N/A
22	Double	1,521	439	N/A	12
	Setover(2)	157	55	21	N/A
	Knockout(3)	85	6	4	N/A

Notes: (1) Tow breakup refers to the process of decoupling a tow so that it can be locked through a chamber. Tow makeup refers to the amount of time required to recouple a tow after it has moved through a chamber.
(2) Upbound traffic only.
(3) Downbound traffic only.

Source: U.S. Corps of Engineers, 1977 PMS data.

EXHIBIT III-13

U.S. ARMY CORPS OF ENGINEERS
ROCK ISLAND DISTRICT

LOCATIONS CITED BY CARRIERS AS
POTENTIAL NAVIGATIONAL CONSTRAINTS

Pool	River Mile	Reference Point
11	610	Island 189
11	599	Hurricane Island
11	596	Finley's Landing
12	566	Gordon's Ferry
13	551-553	Pleasant Creek to Sand Prairie
13	540	Santa Fe Island
13	538	Savanna, IL Crossing to Sabula
13	531	Dark Slough Foot Light
14	503-505	Cordova Slough
14	496	Smith Chain
15	491-488	Campbell's Light to Moline Gap Lighted Buoy
16	472	Buffalo Towhead
16	460	Hershey Chute Red Buoy
17	448	Muscatine Prairie Foot Light
18	431	Edward's River
18	426	Keithsburg
18	425	Huron
18	416	Oquawka Lower
19	398-401	Kemp's Landing
20	355	Fox Island
20	350	Curtis
22	312	Walkers Slough
22	304	Long Hollow Light Buoy

Source: Field interviews.

U.S. ARMY CORPS OF ENGINEERS
ROCK ISLAND DISTRICT

BIBLIOGRAPHY FOR REVIEW OF COMMERCIAL DEVELOPMENT

Dairyland Power Cooperative, Statement of Norman W. Moser before Corps of Engineers, March 1977.

Dalton, Dalton & Newsport: Management Consultants, Quad Cities Urban Study, October 1978.

Davenport Levee Improvement Commission, Environmental Impact Statement Davenport Municipal Barge Terminal, March 1977.

Des Moines Sunday Register, Planned Barge Moorings Rapped as Ugly Polluters, March 18, 197[illegible]

Environmental Impact Statement, Borg Warner Plastics Plant, Saverton, Missouri, December 1978.

Great River Environmental Action Team, GREAT I Commercial Transportation Workgroup, Great River Resource Management Study, January 1979.

Illinois Department of Conservation, Outdoor Recreation in Illinois, December 1978.

Iowa Department of Transportation, Iowa Transportation Improvement Program 1979-1984, December 1978.

Iowa Department of Transportation, River Transportation in Iowa, May 1978.

Iowa Department of Transportation, Transplan '79, January 1979.

Kearney: Management Consultants, Domestic Waterborne Shipping Market Analysis, February 1974.

Kearney: Management Consultants, A Primer on Inland Waterways Ports.

Kearney: Management Consultants, Recommendations for River-Related Economic Development of Missouri, September 1978.

Marcou, O'Leary and Associates, Inc., Findings from the Surveys and Analyses of the Proposed Municipal Barge Terminal at Davenport, Iowa, June 1974.

McMahon, Thomas J., The Statement of Thomas J. McMahon made concerning commercial development of Upper Mississippi River, January 1977.

BIBLIOGRAPHY FOR REVIEW OF COMMERCIAL DEVELOPMENT (Cont'd.)

Toltz, King, Dewall, Anderson & Association Incorporated, Report on Proposed Municipal Barge Terminal, June 1973.

Upper Mississippi River Basin Commission, The Upper Mississippi River Main Stem, Water and Related Land Resources, Draft Study Report and Environmental Assessment, including technical papers A-K, March 1979.

Upper Mississippi River Conservation Committee, A Compendium of Fishery Information on the Upper Mississippi River, January 1979.

Upper Mississippi Water Association, The Economic Impact of Waterborne Transportation on the Upper Mississippi River Basin, July 1975.

U.S. Corps of Engineers, Economic Analysis of Year-Round Navigation on the Upper Mississippi, June 1979.

U.S. Corps of Engineers, Mississippi River Year-Round Navigation Study, September 1973.

U.S. Corps of Engineers, Upper Mississippi Small Crafts Lock Study, September 1977.

U.S. ARMY CORPS OF ENGINEERS
ROCK ISLAND DISTRICT

COMPANIES CONTACTED BY A. T. KEARNEY
FOR REVIEW OF COMMERCIAL DEVELOPMENT PROBLEMS(1)

Alter Company

Bi-State Planning Commission

Chamber of Commerce for Bettendorf, Iowa

Chamber of Commerce for Burlington, Iowa

Chamber of Commerce for Clinton, Iowa

Chamber of Commerce for Davenport, Iowa

Chamber of Commerce for Dubuque, Iowa

Chamber of Commerce for Fort Madison, Iowa

Chamber of Commerce for Hannibal, Missouri

Chamber of Commerce for Keokuk, Iowa

Chamber of Commerce for Moline, Illinois

Chamber of Commerce for Muscatine, Iowa

Chamber of Commerce for Quincy, Illinois

Chamber of Commerce for Rock Island, Illinois

Continental Grain

Davenport Levee Improvement Commission

Department of Conservation for the State of Missouri

Department of Conservation for the State of Illinois

Department of Economic Development for the State of Minnesota

Department of Economic Development for the State of Illinois

Department of Environmental Quality for the State of Iowa

Department of Natural Resources for the State of Minnesota

Dairyland Power Co-Op

Environmental Protection Agency in Chicago and Kansas City

U.S. ARMY CORPS OF ENGINEERS
ROCK ISLAND DISTRICT

COMPANIES CONTACTED BY A. T. KEARNEY
FOR REVIEW OF COMMERCIAL DEVELOPMENT PROBLEMS (Cont'd.)

Farmers Union Grain Terminal Association

Iowa Gateway Terminal

Maritime Administration

Mensinger Fish and Seafood Company

Mississippi River Parkway Commission

Pillsbury Company

Quad City Development Association

Rock Island District Corps of Engineers

Stanley Consultants

Twin Cities Towing

University of Minnesota

Upper Mississippi Conservation Commission

Upper Mississippi River Basic Commission

Upper Mississippi Waterway Association

U.S. Fish and Wildlife Service

Wisconsin Barge Line

Note: (1) List does not include two firms who choose to remain anonymous.

U.S. ARMY CORPS OF ENGINEERS
ROCK ISLAND DISTRICT

DISTRICT PUBLIC TERMINAL LOCATIONS

Terminal Name	City	Mile Number
Quincy Terminal Company	Quincy, Illinois	326.0
Iowa Gateway Terminal	Keokuk, Iowa	371.1
Hall Towing, Inc.	Fort Madiscn, Iowa	382.0
Burlington River Terminal, Inc.	Burlington, Iowa	405.3
The Pillsbury Company	Davenport, Iowa	475.7
Rock Island River Terminal	Rock Island, Illinois	480.8
Alter Trucking and Terminal Corporation	Davenport, Iowa	483.3
Determann Industries, Inc.	Camanche, Iowa	512.0
Clinton Municipal Dock	Clinton, Iowa	518.0
Fulton River Terminal	Fulton, Illinois	517.5
Dubuque Tank Terminal Company	Dubuque, Iowa	579.4
The Pillsbury Company	Dubuque, Iowa	580.0
ContiCarriers and Terminals, Inc.	Dubuque, Iowa	580.3

Sources: Illinois Department of Transportation.
Wisconsin Department of Transportation.
Iowa Department of Transportation.
River Transportation in Iowa.
Waterways Journal, Inland River Guide 1978.

U.S. ARMY CORPS OF ENGINEERS
ROCK ISLAND DISTRICT

DISTRICT PRIVATE TERMINAL LOCATIONS

Terminal Name	City	Mile Number
Universal Atlas Cement Co.	Ilasco, Missouri	305.7
Hannibal Grain Terminal	Hannibal, Missouri	309.0
Hannibal Iron and Metal Co.	Hannibal, Missouri	309.5
Bunge Corporation	East Hannibal, Illinois	310.0
Scipio Land Co.	Hannibal, Missouri	310.8
American Cyanamid Co.	Palmyra, Missouri	319.8
Northeast Missouri Electric Power Co-Op.	Palmyra, Missouri	320.3
Consolidated Oil Company	Quincy, Illinois	325.7
Illinois Ayers Oil Company	Quincy, Illinois	325.8
Quincy Soybean Company	Quincy, Illinois	325.8
Quincy Municipal Barge Dock	Quincy, Illinois	326.1
Celotex Corporation	Quincy, Illinois	326.3
Moorman Manufacturing Co.	Quincy, Illinois	326.4
Quincy Sand Company	Quincy, Illinois	327.3
LaGrange Elevator Co.	LaGrange, Missouri	335.7
Triangle Refineries	LaGrange, Missouri	335.8
Ayers Oil Company	Canton, Missouri	342.6
Ursa Farmers Cooperative	Meyer, Illinois	343.4
Gabe Logsdon & Sons	Gregory, Missouri	353.0
Morgan Oil Company	Alexandria, Missouri	359.2
Hancock Grain Company	Warsaw, Illinois	359.7

DISTRICT PRIVATE TERMINAL LOCATIONS (Cont'd.)

Terminal Name	City	Mile Number
Toledo, Peoria and Western Railroad	Warsaw, Illinois	359.9
Foote Mineral Company	Keokuk, Iowa	362.0
The Hubinger Co.	Keokuk, Iowa	362.3
Hunold Elevator, Inc.	Montrose, Iowa	374.9
Colusa Elevator Co.	Nauvoo, Illinois	376.4
Apple River Dock (St. Paul Ammonia Products)	East Dubuque, Illinois	385.1
First Miss, Inc.	Fort Madison, Iowa	389.0
Green Bay Grain Co.	Wever, Iowa	390.0
Central Soya Company	Dallas City, Illinois	390.4
AMOCO Oil Company	Burlington, Iowa	399.4
Archer-Daniels-Midland Co.	Burlington, Iowa	403.6
Gulfport Terminal	Burlington, Iowa	404.2
Yetter Oil Company	Burlington, Iowa	404.5
Wayne Bros. Grain Co.	Burlington, Iowa	405.2
Gladstone Terminal	Smithshire, Illinois	409.7
Altier Trading Corporation	Oquawka, Illinois	415.6
AGRI Industries	Meekers Landing, Iowa	418.2
Big River Grain Dock	Keithsburg, Illinois	423.7
Central Soya Company	New Boston, Illinois	433.0
Monsanto Agricultural Products Company	Muscatine, Iowa	449.9

DISTRICT PRIVATE TERMINAL LOCATIONS (Cont'd.)

Terminal Name	City	Mile Number
Farmland Industries	Muscatine, Iowa	450.3
W. G. Block Company	Muscatine, Iowa	451.2
River Terminal Corp.	Muscatine, Iowa	451.3
Muscatine Power and Water Co.	Muscatine, Iowa	452.9
AGRI Industries	Muscatine, Iowa	453.2
Grain Processing Corp.	Muscatine, Iowa	453.8
Central Soya Co.	Muscatine, Iowa	454.2
Central Soya Co.	Muscatine, Iowa	455.3
Eastern Iowa Light and Power	Montpelier, Iowa	468.0
Alter Company	Montpelier, Iowa	469.6
Cargill, Inc.	Montpelier, Iowa	469.8
Dewey Portland Cement Co.	Linwood, Iowa	474.7
Linwood Stone Products Co.	Linwood, Iowa	475.3
Macmillan Oil Company	Linwood, Iowa	475.5
AMOCO Oil Company	Linwood, Iowa	475.4
Mississippi River Grain Elevator	Buffalo, Iowa	476.0
W. G. Block Company	Walnut Grove, Iowa	477.8
Illinois Oil Products	Rock Island, Illinois	480.8
River Barge Terminal	Rock Island, Illinois	480.9
Dundee Cement Company	Rock Island, Illinois	481.3
Builder's Sand and Gravel Co.	Davenport, Iowa	483.2
W. G. Block Company	Davenport, Iowa	483.3

DISTRICT PRIVATE TERMINAL LOCATIONS (Cont'd.)

Terminal Name	City	Mile Number
Moline Consumers Company	Moline, Illinois	486.4
Universal Atlas Cement	Bettendorf, Iowa	486.8
Mobil Oil Corporation	Bettendorf, Iowa	487.0
Shell Oil Company	Bettendorf, Iowa	487.0
AMOCO Oil Company	Bettendorf, Iowa	487.1
Bettendorf Terminal	Bettendorf, Iowa	487.5
Phillips Petroleum Co.	Bettendorf, Iowa	487.2
Texaco, Inc.	Bettendorf, Iowa	487.7
W. H. Barber Company	Bettendorf, Iowa	488.4
International Harvester	East Moline, Illinois	488.7
LeClaire Quarries, Inc.	LeClaire, Iowa	498.2
Quad Cities Nuclear Power	Cordova, Illinois	506.8
Northern Gas Products Co.	Cordova, Illinois	508.0
CF Industries, Inc. (fertilizer)	Cordova, Illinois	509.5
FS Services	Albany, Illinois	509.9
W. G. Block Company	Camanche, Iowa	513.5
E. I. du Pont de Nemours	Camanche, Iowa	513.9
Interstate Power Co.	Camanche, Iowa	514.2
Bunge Corporation	Albany, Illinois	514.3
Peavy Company	Clinton, Iowa	517.2
Clinton Corn Processing	Clinton, Iowa	517.5
Agrico Chemical Co.	Fulton, Illinois	519.0
CF Industries, Inc.	Clinton, Iowa	521.0

DISTRICT PRIVATE TERMINAL LOCATIONS (Cont'd.)

Terminal Name	City	Mile Number
Savanna Terminal	Independence, Iowa	537.2
USS Agri-Chemicals Co.	Bellevue, Iowa	559.0
N-REN Corporation	East Dubuque, Illinois	572.9
Sinclair Marketing, Inc.	Dubuque, Iowa	579.2
Dubuque Twine Company	Dubuque, Iowa	579.3
Molo Sand and Gravel Co.	Dubuque, Iowa	579.5
Interstate Power Co.	Dubuque, Iowa	580.0
Dubuque Oil Company	Dubuque, Iowa	580.1
Dubuque Tank Terminal Co.	Dubuque, Iowa	580.3
Dairyland Power Cooperative	Cassville, Wisconsin	606.2
Wisconsin Power & Light Co.	Cassville, Wisconsin	606.8
Cassville River Terminal	Cassville, Wisconsin	608.1

Sources: Illinois Department of Transportation.
Wisconsin Department of Transportation.
River Transportation in Iowa (Iowa Department of Transportation).
Inland River Guide 1978 (Waterways Journal).

U.S. ARMY CORPS OF ENGINEERS
ROCK ISLAND DISTRICT

FLEETING LOCATIONS IN THE DISTRICT

Pool(1)	Descending Side of River	River Mile Location	Operator
11	Right	606-608	Wisconsin Barge Lines, Inc.
12	Right	581	Newt Marine Service
12	Right	580	Wisconsin Barge Lines, Inc.
12	Left	579	Newt Marine Service
12	Left	579	Unknown(2)
12	Left	576-577	Newt Marine Service
14	Left	518	Lewis & Lawson Harbor Service, Inc.
14	Right	517	Lewis & Lawson Harbor Service, Inc.
14	Right	516-517	Lewis & Lawson Harbor Service, Inc.
16	Left	475-476	Williams Marine Enterprise, Inc.
16	Left	472-473	Williams Marine Enterprise, Inc.
17	Right	454	Williams Marine Enterprise, Inc.
17	Left	453-454	Williams Marine Enterprise, Inc.
18	Left	432	R & R Marine
18	Left	428	Lee County Marine, Inc.
18	Left	427	Lee County Marine, Inc.
18	Right	418	R & R Marine
19	Left	407	Unknown(2)
19	Right	405	P-D Harbor Service Co.
19	Left	405	Unknown(2)
19	Right	383	Hall Towing, Inc.
19	Right	371	Iowa Marine Repair Corp.
20	Right	364	Canton Towing Service

FLEETING LOCATIONS IN THE DISTRICT (Cont'd.)

Pool(1)	Descending Side of River	River Mile Location	Operator
20	Right	360-361	Iowa Marine Repair Corp.
20	Right	360	Canton Towing Service
20	Left	346	Canton Towing Service
21	Right	335	Canton Towing Service
21	Right	328	Canton Towing Service
21	Left	327	Canton Towing Service
21	Right	327	Canton Towing Service
22	Left	310	Canton Towing Service
22	Left	309	Canton Towing Service

Notes: (1) Pool refers to individual river segments between dams.
(2) Fleeting at this spot was observed by a Coast Guard officer, but the operator was not identified.

Sources: Field interviews.
U.S. Corps of Engineers.
U.S. Coast Guard.

U.S. ARMY CORPS OF ENGINEERS
ROCK ISLAND DISTRICT

PROJECTED ORIGINATIONS AND TERMINATIONS IN THE DISTRICT
(Thousands of Tons)

Pool(1)	1977	1980	1990	2000
11	681	759	1,251	1,456
12	1,533	1,716	2,319	2,831
14	1,954	2,238	3,481	4,562
15	1,044	1,181	1,686	1,982
16	1,651	1,969	2,854	3,719
17	682	821	1,131	1,463
18	597	735	1,037	1,388
19	2,005	2,411	3,311	4,417
20	408	505	715	1,000
21	1,003	1,198	2,006	3,024
22	814	963	1,353	1,744

Note: (1) Individual river segment corresponding to each dam.

Source: DRI Transportation Service.

IV - RECOMMENDATIONS

This study is directed to the Commercial Transportation Workgroup of the GREAT II project. Its purposes were to forecast barge traffic in the Rock Island District of the Corps and identify potential constraints that might reduce the growth of barge traffic in the future. The findings and conclusions with regard to the barge traffic forecasts are presented in Section II. The findings and conclusions with regard to the analysis of constraints are presented in Section III.

The recommendations to the Commercial Transportation Workgroup developed from this study are presented below:

1. The Corps should consider constructing a mooring cell just north of Lock 22 as soon as possible to meet present needs.

2. While the mooring cell is being constructed, the Corps should consider locking tows at Lock 22 in sequences of three or four up and three or four down during peak traffic periods.

3. The Corps should make average lock processing ti s for each lock available to the barge and towing industry.

4. The barge and towing industry should seek to reduce lock processing time by continuing to improve crew training.

5. The Corps should consider extending upper and lower guidewalls first at Lock 22 and then at Locks 21 and 20 within the next five years.

6. Once the guidewalls have been extended at Locks 2 21, and 20, the Corps should consider restricting the makeup of doubles and the makeup and breakup of setovers and knockouts to areas away from the lock chamber gates during peak periods.

7. Within the next five to ten years, the Corps should consider the possibility of constructing additional lock capacity at Lock 22 and then Lock 21.

8. In order to maintain a channel for safe and efficient navigation, the Corps should find low-cost dredge disposal sites for the following areas:

(a) Island 189 (pool 11 and river mile 610).

(b) Hurricane Island (pool 11 and river mile 599).

(c) Gordon's Ferry (pool 12 and river mile 566).

(d) Savanna, Illinois crossing to Sabula (pool 13 and river mile 538).

(e) Dark Slough Foot Light (pool 13 and river mile 531).

(f) Keithsburg (pool 18 and river mile 426).

(g) Huron (pool 18 and river mile 425).

(h) Oquawka Lower (pool 18 and river mile 416).

(i) Kemp's Landing (pool 19 and river miles 398 to 401).

(j) Curtis (pool 20 and river mile 350).

9. The Corps should consider increasing the channel width at Edward's River (pool 18 and river mile 431) and Campbell's Light to Moline Gap Lighted Buoy (pool 15 and river miles 491 to 488) by cutting additional rock.

10. The Corps should consider increasing the channel depth at Smith Chain (pool 14 and river mile 496) by cutting additional rock.

11. Navigational aids should be checked and reset by the Coast Guard on a more frequent basis.

12. The placement of navigational aids should be given special attention at:

(a) Maquoketa Light and Red Buoy (pool 11 and river mile 589).

(b) Gordon's Ferry (pool 12 and river mile 566).

(c) Campbell's Light to Moline Gap Lighted Buoy (pool 15 and river mile 491).

(d) Moline Gap (pool 15 and river mile 488).

(e) Hershey Chute and Red Buoy (pool 16 and river mile 460).

13. Bridge operators should be instructed in the need to open bridges well in advance of tow approach.

14. Construction of cells or docks and placement of landfill should be prevented if they restrict bridge approach, passage, and/or exit.

15. The barge and towing industry needs to provide the Corps and Coast Guard with more timely and complete information about navigational hazards.

16. Agencies responsible for the review of river-related development should have a limited period of time in which to state their requirements for obtaining a permit.

17. Agencies responsible for the review of river-related development should state evaluation criteria precisely so that an assessment of environmental impact can be accomplished at a reasonable cost and in a timely fashion.

18. The federal and state governments, shippers, and railroads should work together to maintain and improve rail service to key ports in the district.

19. The federal and state governments should continue to maintain and extend highways serving key inland ports.

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